MARCH 31, 1960

MACHINE DESIGN

A PENTON PUBLICATION — BIWEEKLY

Hydrodynamic Drives

Contents, Page 3

FARNSWORTH

This is a new HiLube® sintered bronze bearing. **It is treated with moly sulfide, is self-lubricating, and holds almost a third more oil than other sintered bronze bearings. It runs cool and quiet at high speeds. It will last far longer than any other bearing of its kind. HiLube is one of many special bearing materials developed by Bound Brook.**

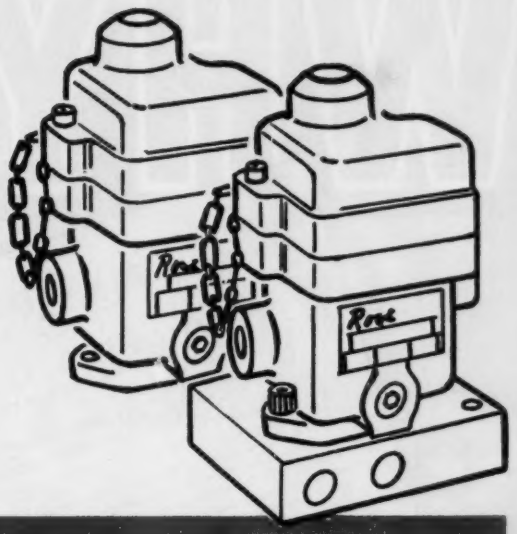
Circle 401 on Page 19

BOUND BROOK

Bound Brook Oil-less Bearing Co., Bound Brook, N. J.
Pioneer in Powder Metallurgy Bearings and Parts.
Plants at Bound Brook, N.J. and Sturgis, Mich.

The Ross PACER gives you 56 new solenoid air valves

The Ross PACER is a fine new solenoid valve in the ⅛" and ¼" size range that gives a full $\frac{1}{12}$" flow capacity yet uses only 7 watts of holding power. The PACER is built for especially long life yet is priced surprisingly low. Capable of 1000 cycles per minute and more, is JIC, and very light and compact. And if you're interested in large valves the PACER has a second identity, that of a pilot section to actuate *any* valve of the Ross Skyline series. It will operate any of these valves at top speed and with low power consumption.

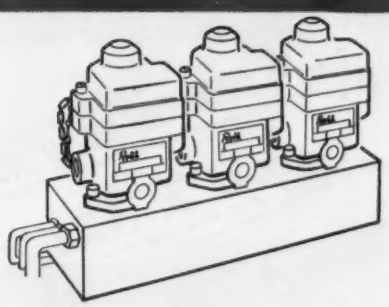


As well as being a complete new valve

...PACER is also a new pilot section in the Ross Skyline valve series...

	PIPE SIZES						
COMPLETE PACER VALVES	⅛"	¼"	⅜"	½"	¾"	1"	1¼"
STRAIGHTWAY, N/C	√	√					
3-WAY, N/C	√	√					
4-WAY	√	√					
SKYLINE VALVES USING PACER AS ACTUATOR (HEAD)							
STRAIGHTWAY, N/C		√	√	√	√	√	√
STRAIGHTWAY, N/O		√	√	√	√	√	√
3-WAY, N/C INLINE MT.		√	√	√	√	√	√
3-WAY N/O, INLINE MT.		√	√	√	√	√	√
3-WAY, N/C, BASE MT.		√	√	√	√	√	√
3-WAY, N/O, BASE MT.		√	√	√	√	√	√
4-WAY, INLINE MT.		√	√	√	√		
4-WAY, BASE MT.		√	√	√	√	√	√
4-WAY, 5-PORT		√	√	√	√		

New **PACER** manifolds to save piping and wiring



Ross manifolds provide a compact and economical method of multiple mounting PACER valves. One air supply line and one electrical conduit can serve all PACER valves. Manifolds are available in two and three stations.

STAY AHEAD

MODERNIZE

ROSS OPERATING VALVE COMPANY

109 EAST GOLDEN GATE AVE. • DETROIT 3, MICH.

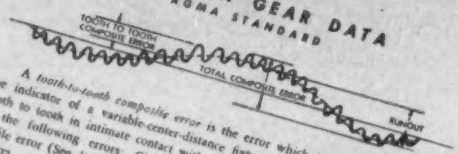
Circle 404 on Page 19

WHY

Have 17,684 Engineers Requested this Catalog?

U. S. GEAR CORPORATION

PRECISION GEAR DATA
AGMA STANDARD



A *tooth-to-tooth composite error* is the error which is shown as flicker on the indicator of a variable-center-distance fixture as the gear is rotated from tooth to tooth in intimate contact with the master. The flicker shows the effect of the following errors: Circular-pitch error, tooth-thickness variation, and profile error (See diagram).

The *total composite error* is made up of runout, lateral runout and the tooth-to-tooth composite error. In other words, this error is the total center distance displacement read on the indicating device (See diagram).

TABLE 1 TOLERANCES FOR COMMERCIAL FINE-PITCH GEARS

Class	Total Composite Error, In.	Tooth-to-Tooth Composite Error, In.
Commercial 1	0.006	0.002
Commercial 2	0.004	0.0015
Commercial 3	0.002	0.001
Commercial 4	0.0015	0.0007

Note: Commercial gears should always be given first preference because they are cheaper to produce. Experience has shown that they are suitable for most fine-pitch applications.

TABLE 2 TOLERANCES FOR PRECISION FINE-PITCH GEARS

Class	Total Composite Error, In.	Tooth-to-Tooth Composite Error, In.
Precision 1	0.001	0.0004
Precision 2	0.0005	0.0003
Precision 3	0.00025*	0.0002

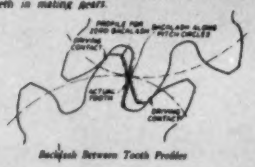
*This possibly would be the result of selection and segregation.

4

U. S. GEAR CORPORATION

PRECISION GEAR DATA
BACKLASH

Backlash is the shortest distance between non-driving tooth surfaces of adjacent teeth in mating gears.



Backlash Between Tooth Profiles

With stock gears, the center distance of two mating gears should be increased over the theoretical center distance to obtain the amount of backlash required.

The amount the center distance should be increased over the theoretically perfect (no backlash) to obtain a specific backlash can be determined as follows:

B = Amount of backlash (inches)

C = Amount to be added to theoretical center distance to obtain required backlash

ϕ = Pressure angle of gear teeth

$$C = \frac{B}{2 \tan \phi}$$

SPECIFIED BACKLASH FOR DIFFERENT CLASSES OF GEARS

Class	Diametral Pitch Range	Backlash in Two Mating Gears of Equal Tooth Thickness on Nominal Center*
A	20 to 45	0.004 to 0.006
	46 to 70	0.003 to 0.005
	71 to 90	0.002 to 0.0035
B	20 to 60	0.002 to 0.004
	61 to 120	0.0015 to 0.003
	121 & Over	0.001 to 0.002
C	20 to 60	0.001 to 0.002
	61 to 120	0.0007 to 0.0015
	121 & Over	0.0005 to 0.001
D	No measurable backlash at any pitch	

*Measured at point of tightest engagement

5

Write for your copy and see!

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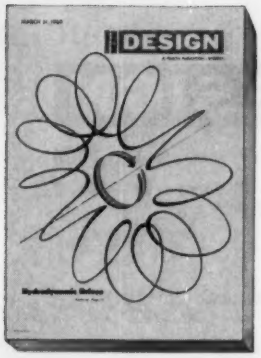
U.S.GEAR

CORPORATION, 81 Baystate Road, Wakefield, Mass.



Front Cover: Around and around it goes as artist George Farnsworth chases a fluid particle in its "round" trip through a hydrodynamic drive. Article in point, Page 108, is the first part of a comprehensive series on hydrodynamic drives. For more on the cover design's execution, see Page 178.

March 31, 1960

CONTINUED NEXT PAGE

THE PROFESSIONAL JOURNAL FOR ENGINEERS & DESIGNERS

MACHINE DESIGN

March 31, 1960
Volume 32 — No. 7

IN THE NEXT ISSUE: Exotic power sources . . . speeding product development . . . flow factors for fluid passages . . . the harmonic drive . . . control-movement direction . . . simplified vibration analysis of combined systems . . . torque converters.

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For tough expansion problems—

ANACONDA
A-X TUBING

Anaconda A-X tubing is a flexible metal connector with annular corrugations designed to handle the types of movement shown at the right while conveying liquids or gases. It is available in stainless steel and other alloys and is generally sold complete with fittings (right, below). Nominal tubing I.D.'s: 5", 6", 8", 10", 12", 14".

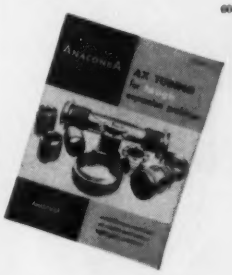
Most axial motion applications involve motion in one direction in respect to the installed position. This may result in compression or extension of the tubing. In a few applications an assembly may be subjected to both extension and compression in relation to the installed length – such cases occur when temperature varies both above and below installation temperature. In order to give the best service for each type of application there are three different corrugation standards for each tubing size:

PRE-COMPRESSED. Designed for extension movement. Will allow a small amount of compression.

STANDARD. Designed for compression movement. Will allow a small amount of extension.

OPEN PITCH. For elbow forming, ducting, or misalignment where little movement is required.

60122



Bulletin A-X 97 gives complete details. Call your Anaconda Metal Hose representative for a copy—or for the services of an Anaconda specialist to help you in the design of a special connector to meet your needs. Or send in coupon below.

ANACONDA® METAL HOSE

Anaconda Metal Hose Division MD
The American Brass Company
Waterbury 20, Conn.

Please send a copy of Bulletin A-X 97

NAME.....

COMPANY.....

STREET.....

CITY..... ZONE..... STATE.....

Circle 406 on Page 19

BASIC STANDARD UNIT

TYPES OF MOTION

AXIAL

RADIAL

DUAL-RADIAL

SHEAR

FITTINGS FOR A-X TUBING—UNBRAIDED

INTEGRAL END

UNW—WELDING NIPPLE

FW—FIXED FLANGE

FFW—FLOATING FLANGE

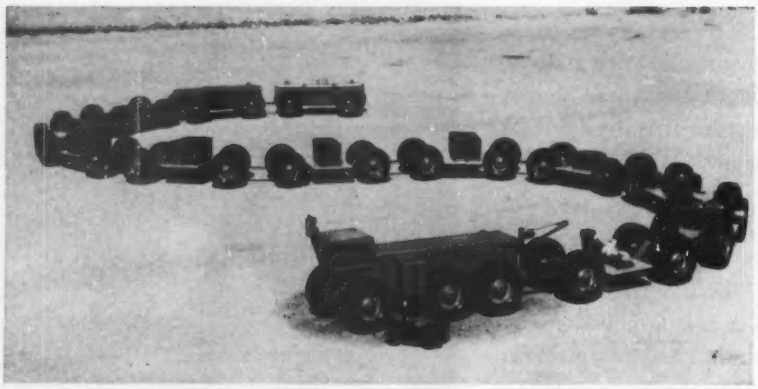
FITTINGS FOR A-X TUBING—BRAIDED

UNW—WELDING NIPPLE

FW—FIXED FLANGE

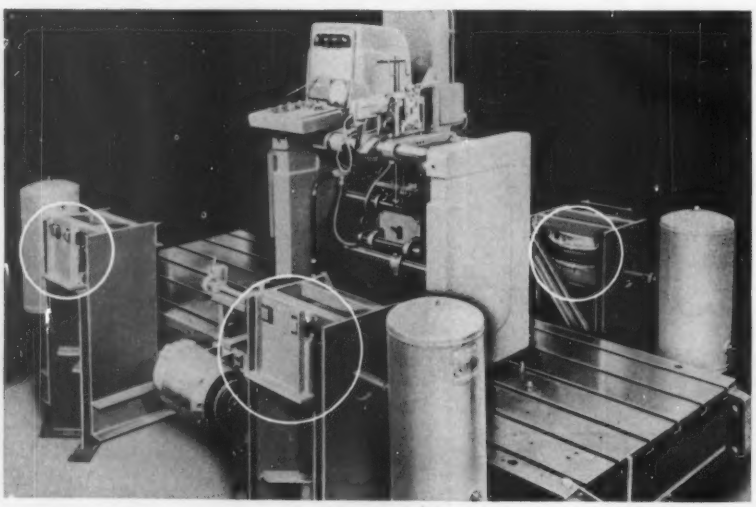
FFW—FLOATING FLANGE

ENGINEERING NEWS



Turbines Will Help Power Army's Overland Train

Four 1000-hp gas-turbine engines will drive the power generators in this electrified overland train. The 13-car unit is propelled by 54 independent drive wheels each containing a high-torque electric motor. Being built for the Army by R. G. LeTourneau Inc., the train consists of a lead control car, ten 4-wheel cargo carriers with a total capacity of 150 tons, and two power cars. One man at an electric console will drive the train, assisted by a navigator and radio man. Steering is controlled through the front wheels of the lead car only, the other 52 cars track automatically through mechanical linkages. Production of the train follows successful tests of a smaller four-vehicle unit now in service.



Air-Ride for Machine Tools

Air bellows designed originally for automobile suspension systems are proving to be an effective means of curing—or creating—machine vibration. They're used to isolate a machine from environmental vibration, to prevent the machine from transmitting vibration to the environment, or as effective vibration actuators (on heavy hoppers, for example). The delicate balancing machine, above, is a typical isolation example. It's mounted on a platform suspended by four bellows. Adjacent tanks supply compressed air. The bellows, fabricated from rubber and nylon, are Firestone Tire & Rubber Co. "Airmounts."

Materials-Research Lag Bottlenecks Space Program

Report by Experts Urges Rare-Metal Stockpiling

WASHINGTON—Poor planning is blamed for a lag in new materials development, in a report published last week by National Academy of Sciences. After a year-long study of the "total materials research and development activities" of the nation, fourteen scientists and executives have reported their findings under the heading of "More Effective Organization and Administration of Materials Research and Development for National Security."

The report states that the lag in the development of new materials is holding back space, nuclear, missile, and rocket programs—almost every field in the national security program. It urges the government to "accord high priority . . . to the science of materials," and notes that substantial inadequacies exist with respect to research programs, personnel resources, and administrative organization.

The report made several recommendations for solving the "materials barrier":

- Co-ordination of government sponsored materials research and development programs is needed, with greater centralization of responsibility.
- Incentives must be provided to encourage the search for new and improved materials.
- Adequate supplies of every material must be assured, to support full use of new materials.
- Dissemination of research information has to be improved and accelerated.
- Training and basic research at universities should be strengthened.

The report further suggests that the government stockpile materials that may be vital to future defense projects. Rhenium and Tantalum were cited as examples.

. . . Fluid Power news

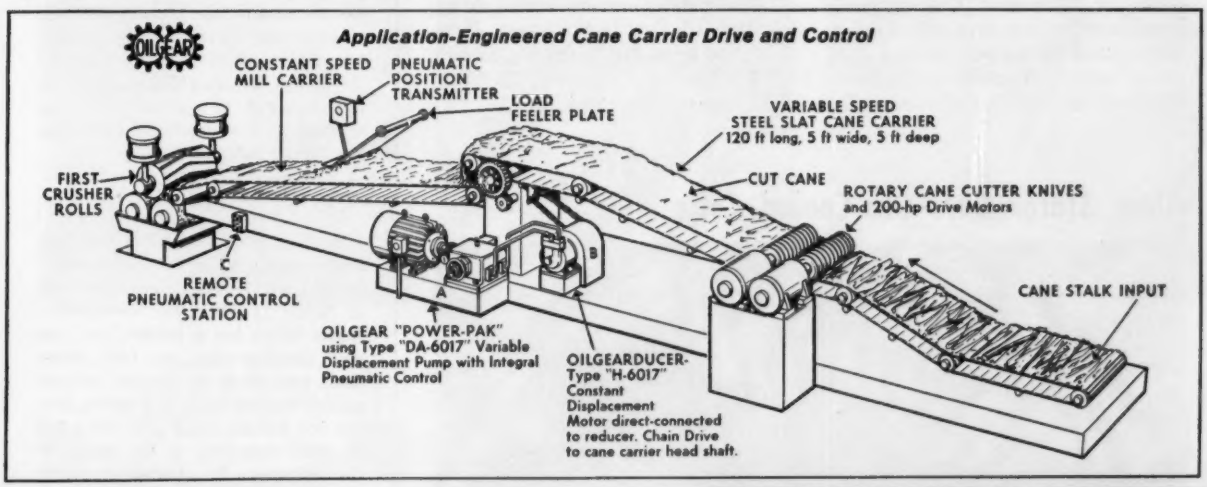
REPORT No. 11,302 "ANY-SPEED" DRIVE UPS MILL EFFICIENCY

From Oilgear Application-Engineering Files

HOW OILGEAR "Any-Speed" DRIVE AND CONTROL SYSTEM AUTOMATED A SUGAR CANE CARRIER

CUSTOMER: A Large Sugar Cane Mill (Name on request).

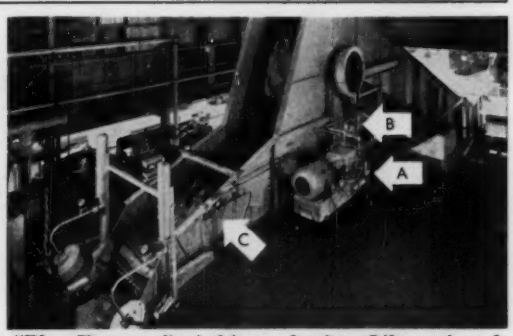
DATA: To increase mill efficiency, and run at maximum capacity by maintaining an optimum flow of cut cane to the crushers, it was necessary to convert a conventional, manually controlled electric cane carrier drive to an automatic, load-sensitive, variable speed drive and control system with the following specific requirements: 1. An infinitely variable speed drive coupled with automatic "sensing" load-speed controls to exactly match cutter and crusher capacity . . . plus instant-stop overload protection as required by the following variables: 1a. Inconsistent carrier loading. 1b. Varying size and physical characteristics of the cane. 1c. Cut cane's tendency to "choke" or pile up at the crusher. 1d. Gradual efficiency loss as cutter knives become dull. 2. Automatic speed control, and stop, related to load. 3. Remote and manual control to start, stop, inch, and infinitely increase or decrease carrier speed. 4. Pneumatic controls, as mill personnel understand them. 5. Dependable, trouble-free for round-the-clock harvest operation, impervious to high humidity and daily washdowns.



SOLUTION: An Oilgear "Any-Speed" Drive and Control System consisting of an Oilgear "Power-Pak," an Oilgearducer, and the pneumatic control system as shown above. This "Power-Pak" uses a Type "DA" Variable Displacement Pump with integral pneumatic control, a constant speed electric motor all mounted on a custom reservoir base. The Oilgearducer consists of an Oilgear Type "H" Constant Displacement Motor direct-connected to a reducer. Operating on a pressure differential of 3 to 15 psi, the integral, pneumatic, pump control system provides stepless, infinitely variable drive speeds from zero to maximum. A completely automatic control system increases or decreases carrier speed in response to preset percentage of knife motor load, and position of the feeler plate on the mill carrier section . . . carrier is instantly stopped by sudden peak overloads on the knife motors, or by raising of the feeler plate above a preset position. Carrier can also be started, stopped, inched, accelerated or decelerated from the remote stations, or with the manual handwheel on the Pump.

OWNER REPORT — after two seasons of operation — *". . . . we began operations this season on January 9. We have been running under automatic operation since, and the results have been beyond expectations."*

Circle 407 on Page 19



Right: A view of above installation. Oilgear "Power-Pak" (A), Oilgearducer (B), and one of the Remote Control Stations (C) are indicated.

Some of the "Plus Features" of this, and other Oilgear installations are: cushioned starts, stops, acceleration and deceleration . . . constant pressure and flood lubrication, and system fluid filtration . . . a "sealed" system, impervious to moisture-hazardous atmosphere . . . complete overload protection . . . long-life, trouble-free, efficient performance. Users say — *"for the lowest cost per year — it's Oilgear!"*

For practical solutions to YOUR linear or rotary Controlled-Motion problems, call the factory-trained Oilgear Application-Engineer in your vicinity. Or write, stating your specific requirements, directly to . . .

THE OILGEAR COMPANY

Application-Engineered Controlled-Motion Systems

1568 WEST PIERCE STREET • MILWAUKEE 4, WISCONSIN

Missile Designers Raise Their Standard

NEW YORK—The missile industry has finally arrived. Its purposes, techniques, and products have advanced to the point where a breakdown in semantics threatens any further progress. In effect, missilemen are getting bogged down in complex terminology.

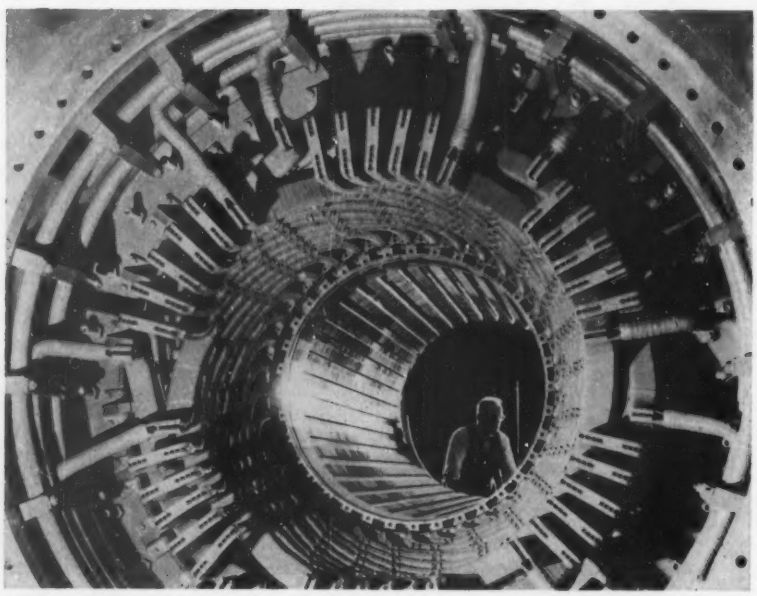
The only cure, of course, is a dictionary of terms, or standards, and one is now available, hot off the presses. Approved by the American Standards Association and published by ASME, the new standard cuts verbal legwork to a minimum.

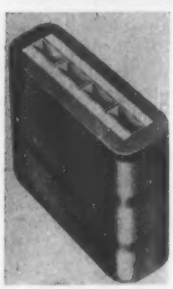
One time-saving symbol, for example, permits specialists to abbreviate the expression "ratio of solid propellant surface area ahead of a given plane to the port area of that plane" simply by writing the letter "G" in italic type. Another example: The letter "H" designates "the area per degree across a boundary surface; film coefficient of heat transfer."

A new concept has been incorporated by the authors of the standard in symbolizing the lessening attraction between a rocket and the earth as the rocket speeds into space. Instead of assuming, as is usually done, that gravity decreases and mass remains constant, space flight has forced the authors of the standard to adopt the opposite concept, that gravity is constant and weight "flows" out of the rocket as it departs from the earth. Standard symbol for this weight flow is an italic "W" with a dot over it.

American Standard Letter Symbols for Rocket Propulsion, Y10.14-1959, is available ($1.50 per copy) from the American Standards Association, 70 East 45th Street, New York, or from the American Society of Mechanical Engineers, 29 West 39th Street, New York 18.

Giant Stator Gets Gas-Cooled Coils





Hydrogen flows through 6000 ft of stainless tubing in a huge new steam turbine generator, keeping stator temperatures low. Current-carrying coils are wrapped around the tubing and both coils and tubing are covered by the main insulation (left). Because heat losses in the coils are transferred to the fast-moving gas stream (up to 10,000 fpm), rather than to the insulation, the generator can be rated at a considerably higher kw capacity than would otherwise be possible. The heat-removal system for the Allis-Chalmers generator was developed by A-C engineers working with Carpenter Steel Co., Union, N. J.

Topics

Fender-to-fender headlight is proposed to the automotive industry by Sylvania. A high-intensity fluorescent lamp, claimed to reduce glare and give more uniform light distribution, would either replace or supplement conventional headlights. In the lamp, an adjustable beam of light comes through a 30-deg window.

• • •

Money isn't everything, but instructors of engineering admit that it's the primary reason they leave colleges for industrial positions. Half of a group of 235 former teachers surveyed by ASEE listed "income and fringe benefits" as a deciding factor in their decisions to leave teaching. Salaries of the group averaged $9800 the first year in industry, compared to $7650 for a year's teaching (including summer-job and consulting income). Over 80 per cent of the erstwhile educators are still interested in teaching and hope to return to it eventually, or when they can "afford it."

• • •

Bowling blind (literally) has been made possible by an "electronic alley" for sightless keglers. Two researchers at Arthur D. Little Inc. developed a system which lets a bowler "feel" the pins standing after the first throw. Small magnets in the bases of the pins operate switches wired to a scoring box; this box has ten small pins which fall or stand according to the action of the switches. By feeling the small pins, a blind bowler can tell which pins are still standing on the alley.

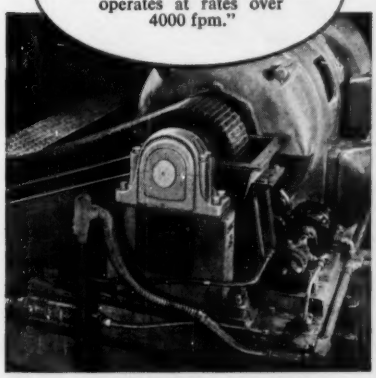
• • •

Concordance by computer, produced with "dazzling speed and relentless accuracy" by an IBM 704 Data Processing System, lists the occurrences of 10,097 words of Matthew Arnold's vocabulary. *A Concordance to the Poems of Matthew Arnold* was prepared and edited by computer at Cornell University Press. A deck of 17,000 cards containing the poet's works was fed into a card reader, which transferred the data to magnetic tape. The computer then searched the tape to index alphabetically every significant word; it listed the entire line in which the word appeared, with identifying information. The computer run took 38 hours; the printing, 10 hours. Print is prepared on finished pages ready for offset reproduction. The concordance contains 965 pages plus an appendix—some 70,000 references.

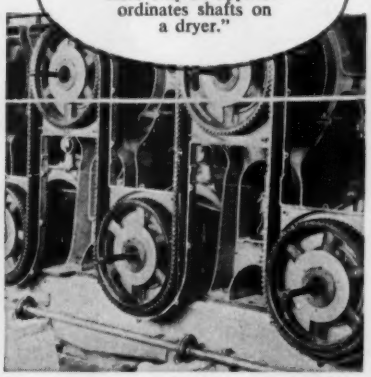
"Here's the story—why so many of

today's designs call for LINK-BELT Silent Chain"

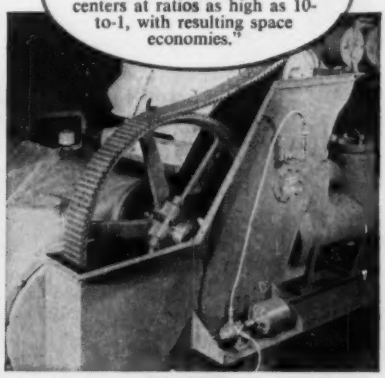
"When it comes to speed, we find Link-Belt Silent Chain is tops. It often operates at rates over 4000 fpm."



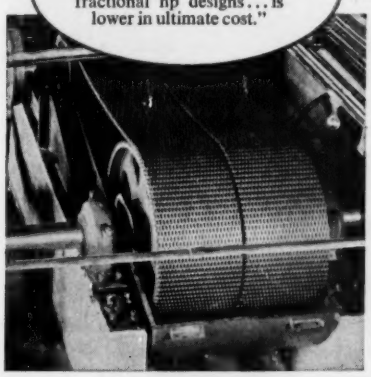
"You can count on Silent Chain for designs calling for accurate timing. Here Duplex Type co-ordinates shafts on a dryer."



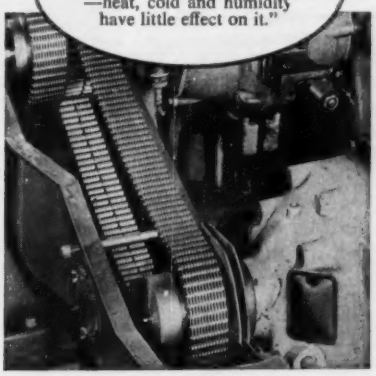
"Silent Chain can be installed on extremely short centers at ratios as high as 10-to-1, with resulting space economies."



"Link-Belt Silent Chain delivers better-than-98% efficiency on large or fractional hp designs... is lower in ultimate cost."



"You can specify Link-Belt Silent Chain confidently under all conditions —heat, cold and humidity have little effect on it."



"In close quarters, as in this belt sander 3/8 in. pitch Silent Chain permits built-in drives, compact housings."

LINK-BELT

SILVERSTREAK SILENT CHAIN DRIVES

FULL DETAILS on Link-Belt Silent Chain are offered in 88-page Book 2425. Get your copy from your Link-Belt office. Look under CHAINS in the yellow pages of your phone book.

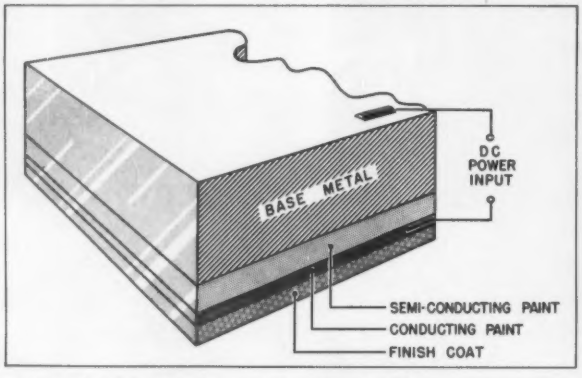
LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Warehouses, District Sales Offices and Stock Carrying Distributors in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs. Representatives Throughout the World. 15,043

Electrolytic Paint:

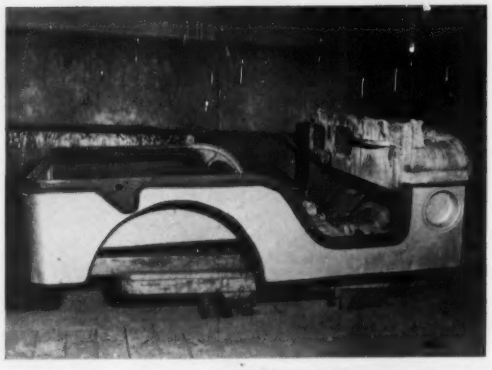
Sure Cure for Corrosion?

DAVID K. WILBURN*
Ord. Tank-Automotive Command
Centerline, Mich.

Wired for protection against atmospheric corrosion, this Jeep will remain exposed for a period of 3 to 5 years.



Layers of semiconducting paint and colloidal copper comprise the electrolyte and anode in OTAC's anticorrosion coating.



Applied to a bare Jeep body, which serves as the cathode, the coating will be covered with olive drab.

LIKE A LATENT DISEASE, the effects of corrosion often remain hidden, emerging to cause sudden and unexpected failure when stress is applied.

This is one reason Army researchers are deeply committed to find a protective coating for the vast inventory of military equipment now in inactive storage. The other reason is perfectly straightforward: Day-to-day deterioration of vehicles and equipment that is clearly visible and enormously expensive.

The latest technique in combating atmospheric corrosion, and one that looks especially promising, is now well into an advanced test program at Army's Ordnance Tank-Automotive Command, Centerline, Mich.

Like other techniques that have been used in fighting corrosion, Army's new method is based on cathodic protection: Voltage is applied to the object being protected, making it cathodic in respect to a common electrolyte.

The key to success of such methods is the existence of a common electrolyte. In the protection of underground pipelines, for example, soil is a convenient electrolyte. Similarly, ships are relatively easy to protect because the water surrounding their hulls permits current transfer. Obviously, in the case of atmospheric corrosion, the principle is not so easily applied. Air does not perform as an electrolyte, and an artificial medium has to be used. This has always posed a major problem.

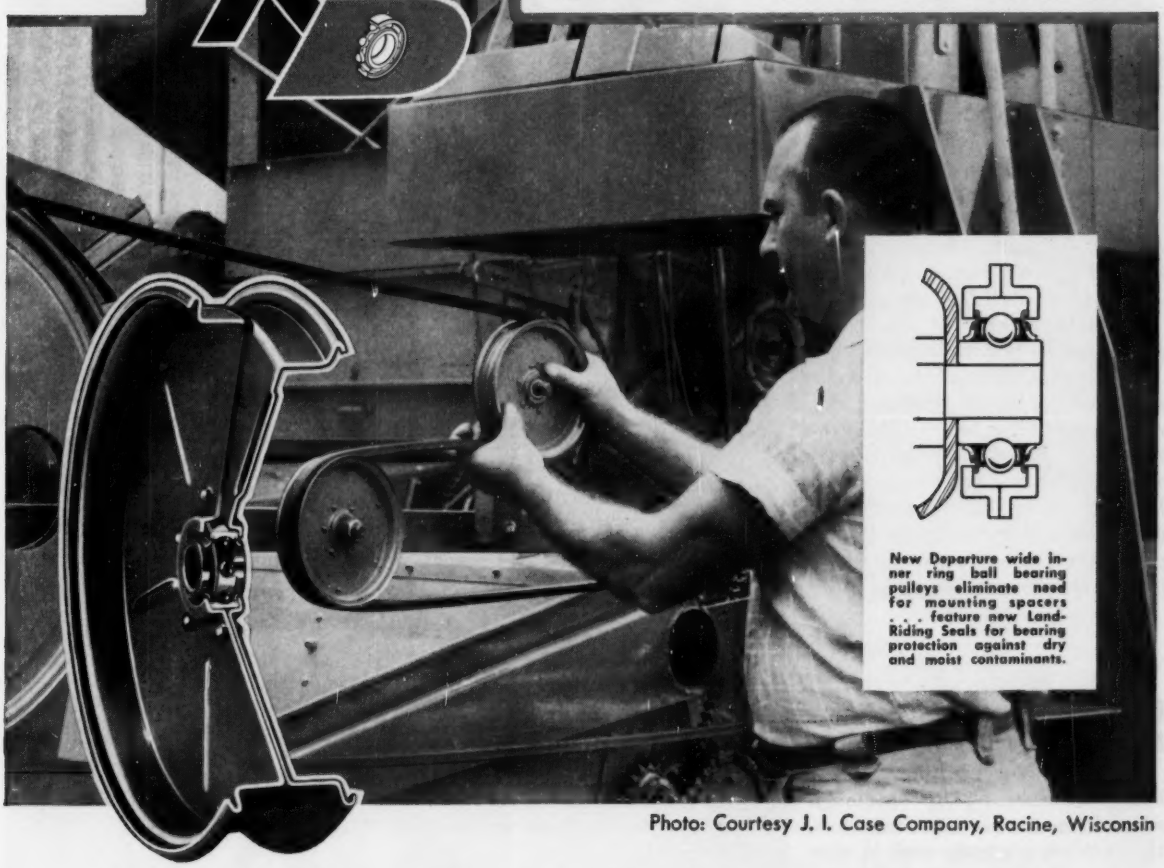
In preliminary research at OTAC, various solid, liquid, and gaseous conductors were evaluated. Electrical conduction and applicability to metal surfaces were primary design requirements.

As a result of their work, OTAC researchers finally came up with a sandwich-like coating which contains, as the electrolyte, a unique semiconducting paint. The anode, a conductive layer of colloidal copper, is applied directly over the paint, and low-level dc is applied to make the protected vehicle cathodic in respect to the copper.

Approximately one year ago,

*Physicist, Physical Sciences Lab., Research Div.

CASE HISTORIES



New Departure wide inner ring ball bearing pulleys eliminate need for mounting spacers . . . feature new Land-Riding Seals for bearing protection against dry and moist contaminants.

Photo: Courtesy J. I. Case Company, Racine, Wisconsin

Idler Pulley Assemblies Help Combine Manufacturer Cut Inventory & Assembly Costs!

CUSTOMER PROBLEM:
Leading farm implement manufacturer experiencing rising costs in the installation of ball bearing pulleys on combines and other farm implements.

SOLUTION:
N/D Sales Engineer, in cooperation with the manufacturer, made an evaluation of pulley applications. He then recommended N/D Land-Riding Seal pulley assemblies containing ball bearings with *wide* inner rings. The wide inner ring paved the way to cutting costs by eliminating conventional spacer inventories. Moreover, the manufacturer now enjoys additional savings because N/D Lubricated-for-Life ball bearing pulleys are *fully assembled* at delivery . . . simplifying inventory even more!

The wide inner ring bearing, butt mounted rigidly against face plate, requires a minimum of parts handling and adjusting at assembly. In addition, these 8" O.D. pulleys have rolled sheave edges for belt protection. All pulleys come with the new and exclusive N/D Land-Riding Seals, factory greased, ready to offer full maintenance-free protection against dry and moist contaminants.

If *you're* a user of flat and "B" section V-Belt pulleys, sizes from 2¾" to 8" O.D., why not check on the savings N/D has to offer? Contact your local N/D Sales Engineer or, write today for the new N/D Idler Pulley Bulletin giving complete specifications and mounting data. New Departure Division, General Motors Corp., Bristol, Conn.

Replacement pulleys available through United Motors System and its Authorized Bearing Distributors.

NEW DEPARTURE
BALL BEARINGS
proved reliability you can build around

Circle 409 on Page 19

OTAC researchers covered a conventional Jeep with the anticorrosion coating, using conventional paint-spraying equipment to apply both the paint and the colloidal copper. Electric power is supplied through a main ground terminal on the vehicle chassis, and to individual printed-circuit electrode on the copper anode. Power requirements are less than 1 volt, at a total output of about 0.4 watts. Because of the small power requirements, the test vehicle is scheduled to get a solar-cell system which will adequately meet daytime power demands.

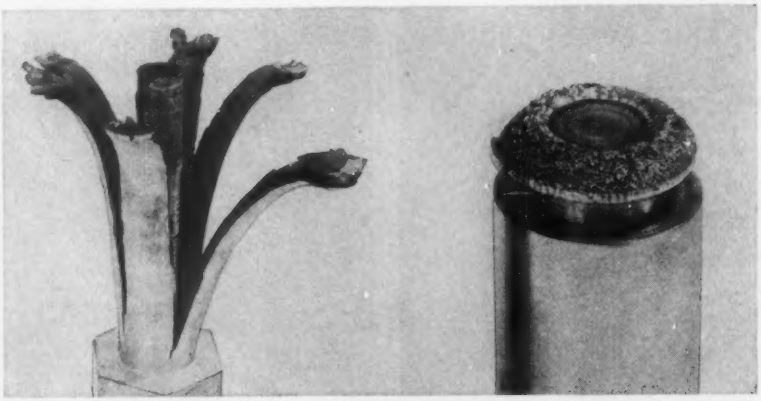
Future possibilities of the cathodic protection system are promising and varied, according to OTAC researchers. Based on prior laboratory successes and confidence in the Jeep test, they believe that their new system may eventually be applied to any metallic structure subject to atmospheric corrosion.

Electronic Traits Prechosen In New Man-Made Diamonds

FORT MONMOUTH, N. J.—Although some diamonds are semiconductors, they are not presently used in electronics. But new synthetic diamonds may be extremely valuable in electronics systems where high temperatures are critical.

In a new process developed at the Army Signal Corps Research and Development Laboratories, the characteristics of man-made diamonds can be controlled. It is done by varying the form of the carbon used, by changing the "impurities" introduced, under close control, or by varying the heat and pressure cycle.

In their synthesis, the Laboratory subjects carbon and metal to 1¼ million psi at temperatures up to 3000 F. Pellets of graphite about 3/16 in. diam are placed in cylinders of heat-resistant compressible mineral material, followed by metal pellets which react with the graphite under the heat and pressure. The cylinders are then sealed and placed in a two-stage pressure chamber. The graphite is heated electrically, and the diamond growth is controlled by the pressure curves. Diamonds up to 1/16 in. in length are produced.



Explosive Fractures, Fragment-Free

Shock waves are focused to produce a clean break in a new line of explosive bolts. This reliance on finesse (right) instead of brute force is expected to minimize fuel-tank puncture and damage to vital black boxes in a variety of missile applications. Developed by Beckman & Whitley, San Carlos, Calif., the fasteners also claim size and weight advantages: They get positive separation with a smaller load, which permits a reduction in over-all bolt dimensions.

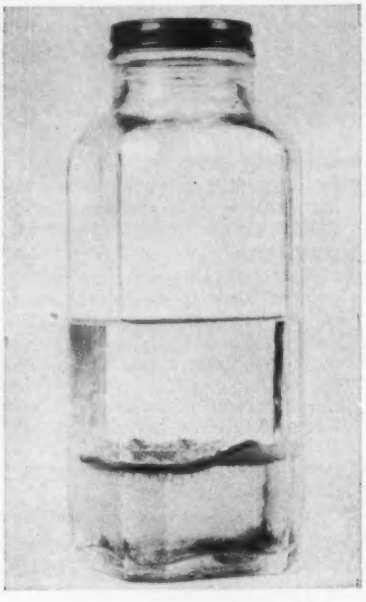
Jet Fuel? Delicious, Say Fungi

Newest addition to the ranks of unforeseen jet-aircraft problems is the compatibility of jet fuel and bacteria: The fuel supports growth of bacteria to the extent that filters and strainers are becoming seriously clogged. And that's not the whole story—fuel is "diluted" through metabolic reactions, and the microbes act as stabilizers for some bizarre new water-fuel emulsions.

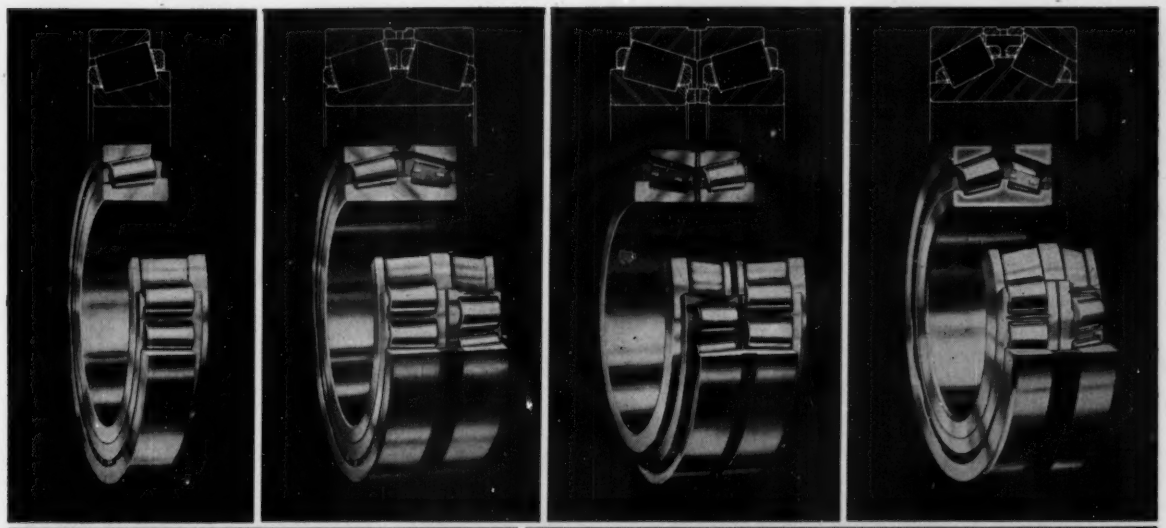
Ability of the organisms to obtain nutrition from jet fuel can be easily demonstrated by adding a small sample from contaminated tanks to an uncontaminated fuel and water mixture. The bacteria immediately attack the carbon in the fuel and soon form a thick scum at fuel-water interfaces. Slimy emulsions are evident on both sides of the boundary.

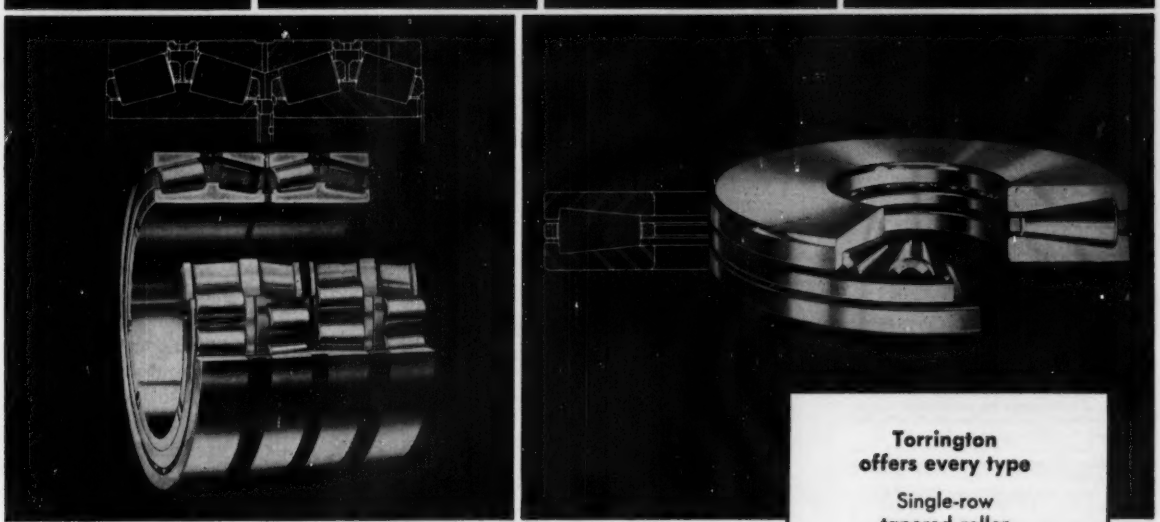
The water must be present—but large storage tanks are especially susceptible to condensation, so eliminating water entirely is not a practical solution. A jet engine's enormous rate of fuel consumption (over 1000 gal per hr) means that, even if small concentrations of water are present in the fuel, residues will build up rapidly in the airplane's tanks.

Since water cannot be eliminated, attention is being focused, by the U. S. Naval Research Laboratory, Washington, D. C., on inhibitors. None of the customary jet-fuel additives work, but two gasoline additives that are compatible with jet fuel offer promise: They seem to be sufficiently toxic to the bacteria at practical concentrations. Answers are not yet final, and several other approaches to jet-fuel biology are also under study.



Thick scum of bacteria forms at the interface between jet fuel and water. The sample is typical of those obtained from contaminated storage tanks.





Torrington offers every type

Single-row tapered roller

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Two-row tapered roller, solid cone

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Two-row tapered roller, solid cup

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Steep angle, two-row tapered roller

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Four-row tapered roller

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Conical roller thrust

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There are single-row, double-row... four-row tapered roller bearings—all in regular or steep angle design for radial and thrust loads—and conical roller thrust bearings for heavy thrust loads. Each is designed for dependable service in its operation.

Whether your application calls for a catalog bearing, or one custom-built to your specifications, you can rely on Torrington for utmost precision of manufacture, quality material, advanced metallurgy... and engineering experience based on the manufacture and application of every major type of anti-friction bearing. **The Torrington Company, South Bend 21, Ind.—and Torrington, Conn.**

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Every Basic Type of Anti-friction Bearing

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Circle 410 on Page 19

Classrooms go automatic with TUTOR

. . . the pushbutton prof

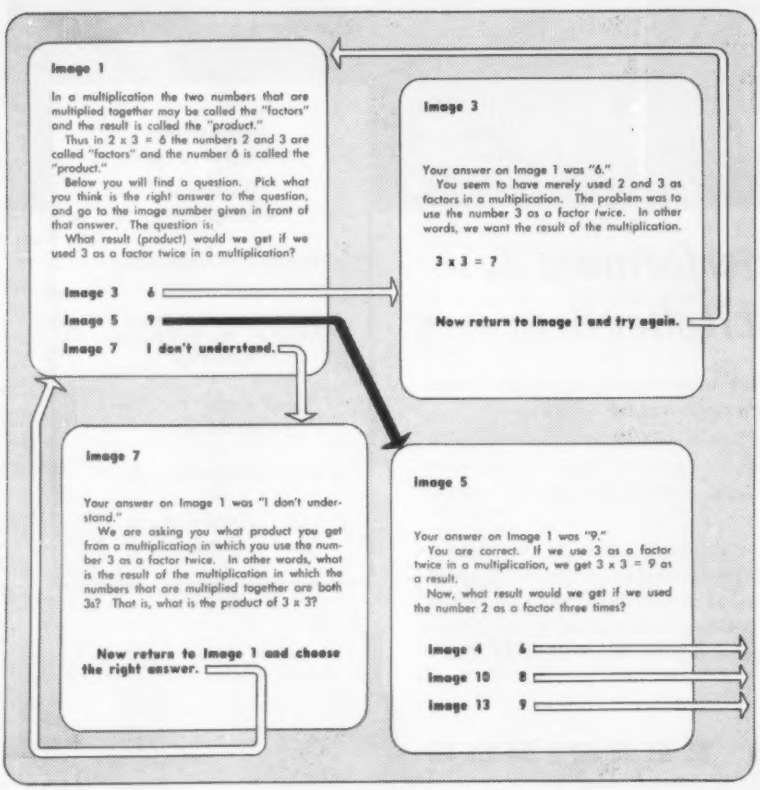
ROBOT professors may soon invade the colleges. Tutor, a sophisticated new teaching machine, swaps ideas with a student—by presenting material, asking questions, and pointing out and correcting errors—then decides when it's time to go on to new material.

Tutor is basically an automatic, random-access microfilm and motion-picture projector with provisions to record answers and time spent on each question. The course of instruction (movies and stills) is contained on a 10,000-frame roll of microfilm. Selector buttons on a keyboard call up each frame as desired.

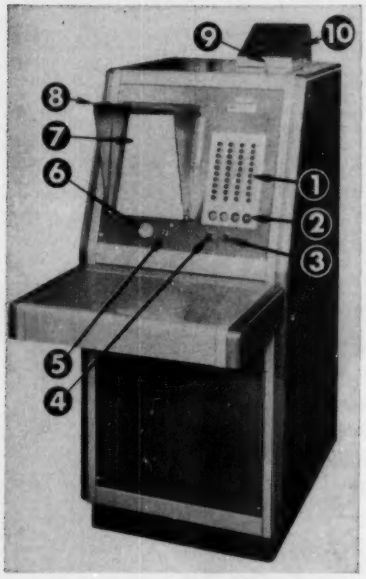
To start the course, the student views the image of the first frame, which contains information, a question, and multiple answers to the question. He punches the keyboard button corresponding to his answer. If he is right, the new image tells him so, presents more theory, another question, and more alternate answers.

If the answer chosen is incorrect, the new image explains why, further discusses the information, and either instructs the student to go back and try again or asks another question on the same material—and gives him a new choice of alternate answers. In no case does the machine let the student go on to advanced material until he understands that which went before.

Motion pictures may be freely intermixed on the same film with microfilm stills. For example, following Image No. 200, a 480-image, 20-sec motion picture could be inserted. The student is instructed (on image 200) to punch the button for image



Tutor teaches by providing facts and asking questions. If it receives a wrong answer, it further explains, then sends the student back to try again. New facts aren't offered until the basics are mastered.



Tutor's control console includes: 1. Selector buttons. 2. Selector indicators. 3. View button. 4. Motion button. 5. On-off switch. 6. Focus control. 7. Viewing screen. 8. Hood. 9. Recorder-tape view window. 10. Recorder-tape and take-up mechanism.

681. Then the intervening images flicker by at 24 frames per second.

One question concerning the motion viewed would be presented on image 681. To study the motion in detail, the student could go back over the 480-frame sequence frame by frame, if he so desired.

Outstanding feature of the machine is its flexibility. The instructor writing the material can use written text, pictures, cross-sectional views, slow-motion sequence shots, or any other techniques necessary or helpful to better understanding. He can insert leading questions, solve example problems in stages, work with analogies, and use all the other modern teaching methods.

The teaching machine will have many applications, says the developer, Western Design Div., U. S. Industries Inc., Santa Barbara, Calif. For example, industry has found that the best techniques for training trouble shooters involve "coach and pupil" relationships and plenty of practice. The machine simulates both the instructor and the equipment and, by correcting the student as soon as he goes astray, constantly peers over his shoulder. It gives him practice in recognizing symptoms and making corrections without an instructor's help.

DRAFTING TRENDS

Inspecting the "locked-in" black image of POST *208TC, Vapo Tracing Cloth, are Mort Fishman of Sabatino & Fishman, Architects, and Mike Ceglia of Bernard Sacks & Associates. Mike Conlin, sales representative of local* POST *dealer, Philadelphia Blueprint Company, looks on.*

Philadelphia engineers save hours per tracing

Remarkable reductions in drafting time, up to 40 hours per tracing, have been achieved by Bernard Sacks & Associates, Philadelphia engineering consultants.

Specializing in heating, plumbing, ventilating, electrical and structural work, this firm receives basic floor plans from architect clients, then makes up separate detailed plans for each construction trade involved.

Bernard Sacks & Associates employs a system using POST 208TC Vapo Tracing Cloth, a positive-to-positive diazo process material. It reproduces with a dense, "locked-in" black image. The original drawing is reproduced on this intermediate product, one for each subcontractor. In most instances, film positives of standard details can be overlaid on the original drawing before the intermediate is made, thus saving considerable drafting time.

Custom details or revisions are drawn directly on the 208TC intermediate, thanks to its excellent ink and pencil line receptivity. The finished plan is a combination of basic floor plan, transparent base overlays and additional drafting. It can be duplicated in quantity by any reproduction process.

POST Tracing Cloth intermediates, as in the above instance, are used in a wide variety of applications by many industries to help reduce costly board time. *For more information on* POST *208TC (black image) or 209TC (sepia image), and how they can help your company produce drawings and prints more economically, write to Frederick Post Company, 3652 Avondale Avenue, Chicago 18, Illinois.*

POST

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Circle 411 on Page 19

HIGH-REDUCTION BEVEL GEARS

To the nine gear types* already made by us for a long list of leading manufacturers, we now add High-Reduction Bevel Gears to meet a growing demand for the economy and speed reduction accomplished by this type of power transmission.

These DOUBLE DIAMOND High-Reduction Bevel Gears will supply speed reduction normally considered impractical in a single gear set of this type. In many cases they will replace more complex and more costly gear systems, thus improving design and achieving simplicity, while considerably lowering costs.

One of our gear engineers would be more than pleased to meet with you to discuss fully the interesting possibilities of this new member of the DOUBLE DIAMOND family.

EATON

AUTOMOTIVE GEAR DIVISION
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GEARS FOR AUTOMOTIVE, FARM EQUIPMENT AND GENERAL INDUSTRIAL APPLICATIONS
GEAR-MAKERS TO LEADING MANUFACTURERS

* Angular bevel gears, Helical gears, Spur gears, Flywheel ring gears, Hypoid bevel gears, Straight bevel gears, Spline shafts, Zerol† bevel gears, Spiral bevel gears. Also gear assemblies.

†REG. U. S. PAT. OFF.

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Reader Information Service

SUBJECT INDEX

Editorial and Advertising content classified by subject and listed by page number for convenience when studying specific design problems. For further information on subjects advertised, refer to advertisement and circle Item Number on a Yellow Card—following page.

MACHINE DESIGN is indexed in the Applied Science & Technology Index and the Engineering Index, available in libraries, generally. Microfilm copies are available from University Microfilms, 313 N. First St., Ann Arbor, Mich.

USE A YELLOW CARD *for More Information . . .*

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Index to New Parts & Helpful Literature

BY ITEM NUMBERS

HELPFUL LITERATURE— descriptions start on page 150

NEW PARTS & ENGINEERING EQUIPMENT— descriptions start on page 154

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NEWS TRENDS

metallurgists start probe of boundary segregation

Why do impure elements in metals tend to segregate at the metal's crystalline boundaries, where they have very important effects on such properties as strength at high temperature, corrosion resistance, ductility, and low-temperature toughness? Answers to this question are being sought by Prof. Philip C. Rosenthal, of the University of Wisconsin's College of Engineering. "In our research, aimed at determining the laws that govern this process, we will start by playing one element against another in controlling boundary segregation. By adding controlled amounts of one element we may prevent the uncontrolled segregation of another element in metals," he says. "Tests have already proved that as little as one-thousandth of one per cent of an element can have a decided effect on the behavior of the metal being treated.

lower and slower for the Air Force

The B-70 may be the last of the ultraperforming manned bombers, but it may not be the last of the bombers. The Air Force is now quietly talking about "Project Dromedary," a big subsonic airplane designed as sort of an airborne prowl car. Conventional jet engines and "ordinary" fuels will keep the slow-moving vehicle aloft for days, making its enemies guess where it is. Advances in missile technology will make the craft a flying missile platform. Both Boeing and Northrop are reportedly involved in the project.

nonengineering subjects attract engineering students

Members of the first freshman engineering class at Columbia University in 45 years say they enrolled primarily because of the opportunity to elect liberal arts courses. Columbia requires a minimum of 32 points in humanities and social studies for an engineering degree, and many students accumulate more than that. The first two years are about equally divided between technical and liberal arts subjects; the third and fourth years, although heavy on engineering, must each include at least one liberal arts course. Before last fall, the engineering school admitted only students who had completed three years at a liberal arts college. Columbia's attitude toward an engineering program is voiced by Wesley J. Hennessy, associate dean of engineering: "Professional engineering implies more than technical competence . . . . It would be improper to award a professional degree without a general education background."

free charge for electrics

Economics, not nostalgia, is reviving the interest in electric cars. As visualized in automotive engineering circles, the electric car of tomorrow will not only be cheaper to operate than today's automobiles, but virtually maintenance-free. The main stumbling block at the moment is battery performance—a recharge is generally needed after 100 miles of travel. One solution to the problem, suggested by International Rectifier Corp., is the use of silicon solar cells to keep the car "gassed up." At the recent American Power Conference, International displayed a 1912 Baker Electric that had 10,000 solar cells mounted on the roof in a detachable 26-sq-ft panel. On a reasonably bright day, the cells are more than adequate to keep the Baker's 72-v battery charged.

seafood in space

Man bites flea may make the news in space circles—it has been suggested that astronauts include such creatures in their diet. Fast-growing, lightweight algae have long been considered the potential staff of life in orbit; however, a human body requires elements which algae do not supply. A tiny crustacean, known as the water flea because of the way it swims, can round out menus by providing proteins, vitamins, minerals, fats, and sugars. It will live and reproduce rapidly in algae tanks carried in space capsules for regenerating air and for food. Researchers working with water fleas maintain that they are palatable—indeed, that they taste like avocado flavored with shrimp.

zero-expansion alloy wants jobs

Developed specifically for electronic applications, a new alloy with virtually zero coefficient of thermal expansion is now looking for work in other fields. According to General Communications Co., Boston, LA-685 Alloy boasts an expansion coefficient of 0.3×10^{-6} in./in./C (for comparison, Invar—1.5×10^{-6}; fused quartz—0.5×10^{-6}). It has proved successful as a cavity material in wave guides and for other electronic jobs, but now GCC is looking for non-electronic applications. The company feels the alloy will be useful wherever structural strength and temperature stability are prime requisites.

four-star rank delayed for computers

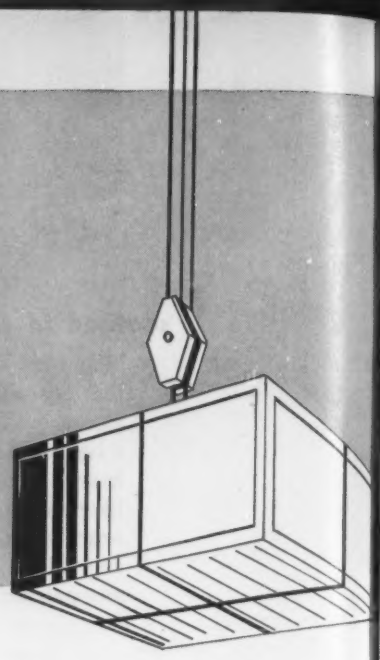
Use of computing machines to control national defense in the atomic era could have serious consequences, according to one of America's top mathematicians. MIT Prof. Norbert Wiener, top authority on cybernetics, explains that a computer is able to take advantage of the many variables that go into a simple game and predict the best possible moves on the basis of its previous experience. It can beat its inventor at checkers after a very brief "learning period," for example. "But the machine for programming atomic war can't get experience from previous wars," says Professor Wiener, so it must learn by playing war games. This, he says, is inadequate training for an electronic brain that is expected to make command decisions.

new personality for polyethylene

It has five times the strength of polyethylene film, exceptional shrinking qualities, and is cellophane clear . . . this is polyethylene film after irradiation. And scientists at W. R. Grace & Co. have succeeded in making this transformation commercially feasible by using available electron-beam machines. In fact, the company has already sold 1000 lb of the "new" film under the tradename of Cryovac Type L. First applications of the material have been in packaging: Subjected to heat, the film shrinks as much as 20 per cent to form a skin-tight package. Until the Grace development, the only irradiated plastics on the market were wire and cable insulating materials, made more heat-resistant by irradiation. The reason: Few plastics can be treated inexpensively by radiation. But researchers in the field still hold high hopes for the process. One particularly promising area appears to be in grafting one plastic to another, which results in a single material with generally improved properties.

No two shipyards are alike. So Navy engineers have turned to scale models of giant portal cranes to come up with the best running gear and track layouts. They're customizing crane facilities from . . .

Table-Top Shipyards



RIDING on rails spaced up to 40 ft apart, portal cranes, generally travel only on straight track. But the Navy finds that they're more useful when they can go around corners—even though running gear wears out faster.

Scale-Model Approach

Engineers at the Naval Civil Engineering Laboratory, Port Hueme, Calif., are experimenting with the running-gear problem. They're using scale models to scrutinize both the gear and track layout. This approach to the problem was adopted for several reasons:

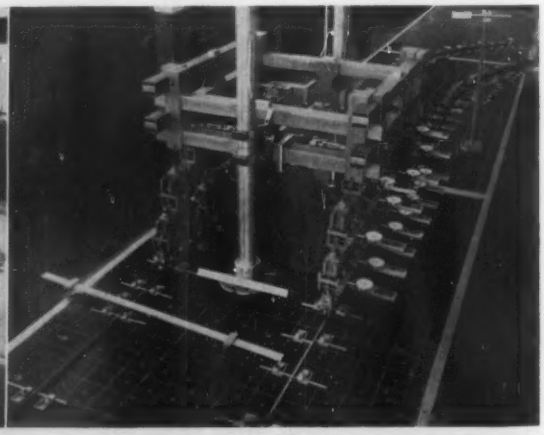
- Cranes are too big to make acceptable subjects for experiments.
- Every naval shipyard must be individually fitted with cranes and track, depending on location of shops, docks, wharves, etc.
- Many types of portal cranes are in use, and each design presents special problems.

Float and Friction

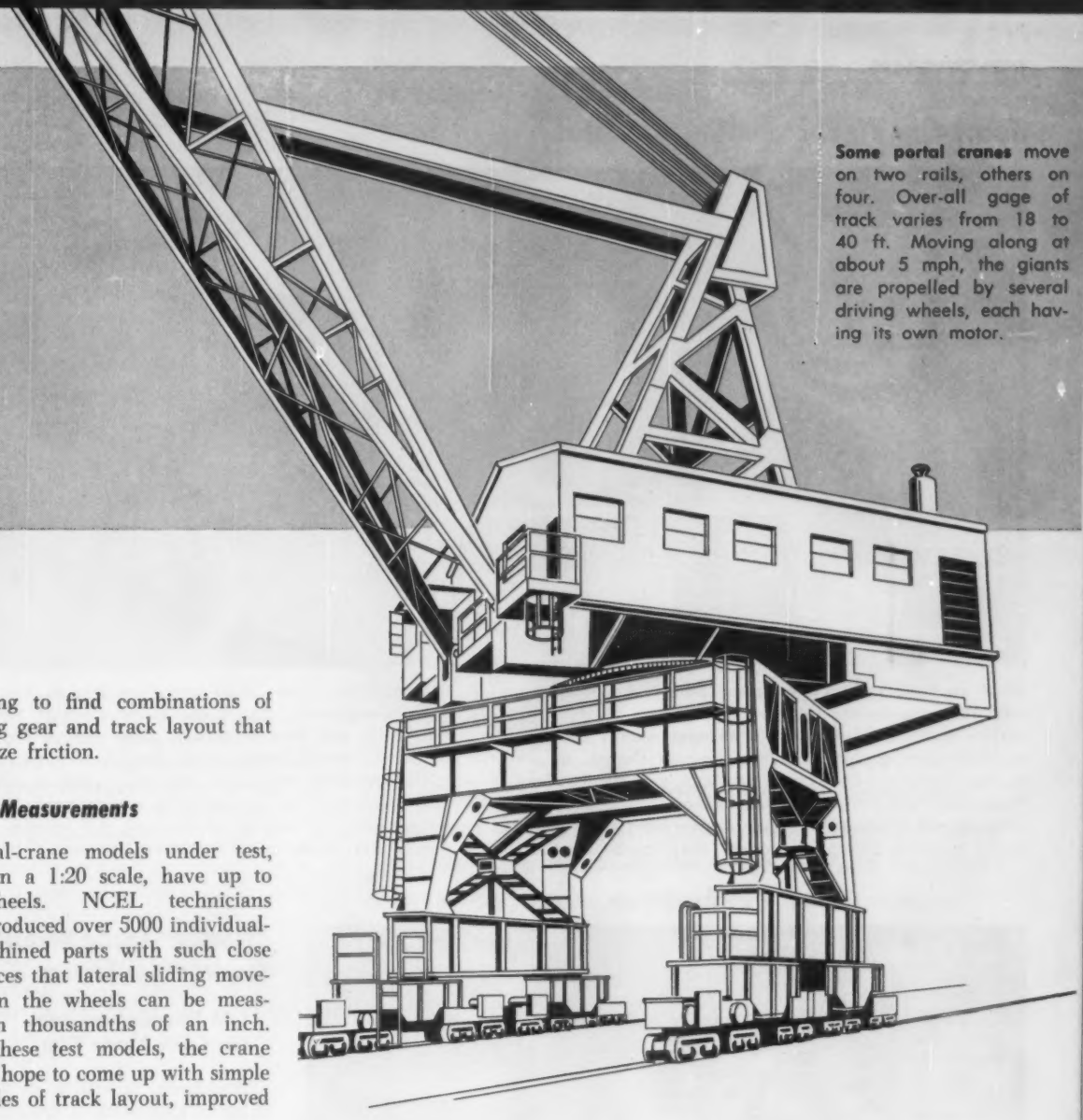
Major problem under study with the scale models is that caused by float. Defined as the linear movement between a portal crane and its running gear, float occurs only when the crane is negotiating a transition between straight track and a curve (or between two simple curves). Effects of float are serious because the great weight of a portal crane—it may have a 75-ton lifting capacity—causes high friction and rapid wear on sliding surfaces.

None of the ways to design running gear for lateral-sliding motions have been found entirely satisfactory, and "gentle" transitions aren't the answer either: Transitions must be abrupt (relative to track width) because of limited track space in a shipyard. So the Navy

Running gear for a portal crane are mated to track layout in the scale-model laboratory. Existing tracks are duplicated on a reduced scale and evaluated, then attempts at improvements are made. Relative to track gage, curves to be negotiated have short-curvature radii.



Displacement gages measure lateral sliding of wheels to thousandths of an inch. By designing transitions between straight track and simple curves from these measurements, the Navy's engineers are able to greatly reduce wear on sliding surfaces, even though they can't eliminate it entirely.

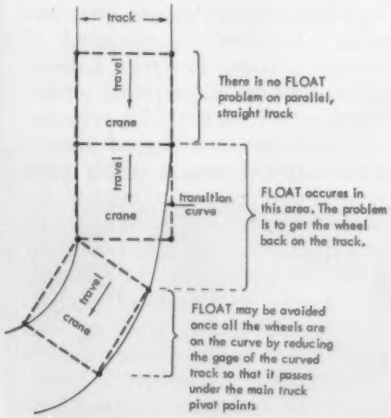


Some portal cranes move on two rails, others on four. Over-all gage of track varies from 18 to 40 ft. Moving along at about 5 mph, the giants are propelled by several driving wheels, each having its own motor.

is trying to find combinations of running gear and track layout that minimize friction.

Close Measurements

Portal-crane models under test, built on a 1:20 scale, have up to 64 wheels. NCEL technicians have produced over 5000 individually machined parts with such close tolerances that lateral sliding movement in the wheels can be measured in thousandths of an inch. With these test models, the crane experts hope to come up with simple principles of track layout, improved running gear, and techniques for predicting wear rates. But this is in the future; their first assignment is to design track layout for those Navy shipyards that now need rehabilitation.



Float occurs only as a transient. When some wheels are on a straightaway and others are on a curve, the trailing end of the crane tries to follow a path different from the leading end.

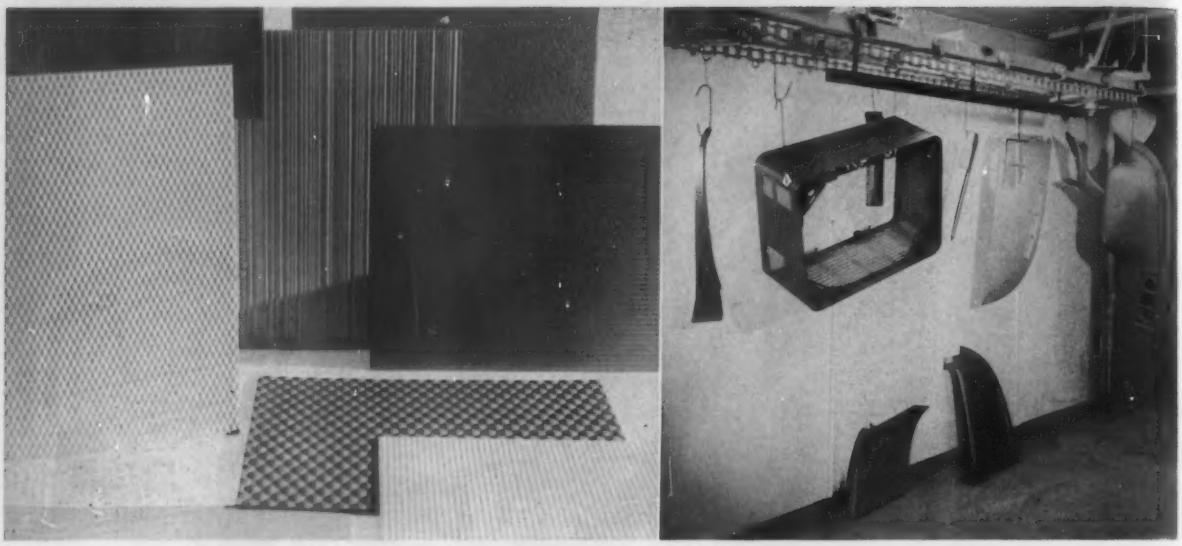
First Application

Model analysis has recently been completed to establish the most satisfactory portal-crane track alignment at Drydock No. 2, Boston Naval Shipyard. Track layout had to closely follow the old track system for reasons of economy, and an S-curve at a turnout complicated the problem.

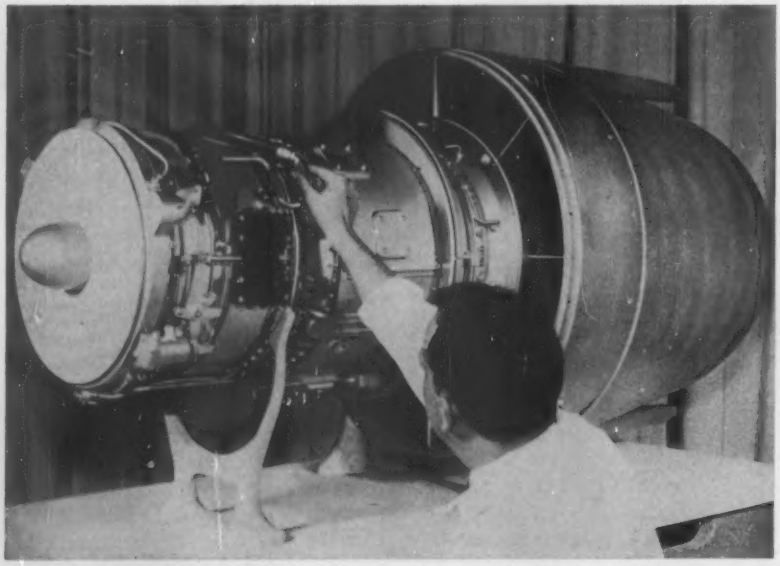
Existing tracks were laid to scale, then later modified, and models of the four different types of cranes in use at the drydock were tested. These cranes range in size from 8 wheels, 20 tons to 32 wheels, 50 tons. Data showed track realignment would reduce wear and maintenance on the running gear appreciably.

Data were then fed into computers to determine the best track layout, and the solution was checked with the models. Revisions "suggested" by the computers are now becoming part of the shipyard.

Spray-On Vinyl



Vinyl coatings are applied after parts fabrication in a new spray-on method using vinyl dispersion finishes. The system works well with plain or textured metals (aluminum or steel) and applies easily to complex shapes, as well as flat surfaces. Developed by Metal and Thermit Corp., New York, spray-on finishes claim these advantages: Applied to the finished part, they require no special care in metal handling during fabrication; they can be applied in the fabricator's own shop using standard or electrostatic spray equipment; rejects can be stripped of their finish chemically and then resprayed; color can be changed as desired by merely changing the spray material; scrap is uncoated, retaining its value, and vinyl waste is eliminated. First application of the coating is a mass-production setup for spraying the interior of domestic dishwashers. Future possibilities: Radio and TV cabinets, automotive trim.



Turbofan Designed for "Compact" Jets

Rated at 4000 lb thrust, with 0.69 specific fuel consumption, General Electric's CF700-1 is the first turbofan engine designed specifically for corporate jet transports. Its first application: McDonnell Aircraft's four-engine 220 executive transport. Weight of the diminutive engine is 585 lb (plus 80 lb for the optional thrust reverser), diameter is 33 in., and over-all length is 70 in. The engine is made up of an eight-stage compressor, two-stage turbine, and single-stage free floating aft fan. By-pass flow ratio is 2 to 1. Price of the new turbofan, with thrust reverser: $70,000.

"Window" Engine Reveals Secrets of Combustion

GM Records Fuel Burn On Color Movie Film

DETROIT—A one-cylinder overhead valve engine with a quartz-topped piston may give new information about the burning of air fuel in high-compression automobile engines. Dr. Fred W. Bowditch of General Motors Research Laboratories described the unusual powerplant at the recent SAE meeting.

The engine is equipped with a unique optical system which takes natural color motion pictures of the air-fuel "burn" exactly as it occurs in automotive engines in service. A series of high-speed color photos has already been made of combustion at compression ratios as high as 10.7 to 1, offering researchers a realistic view of combustion occurring under both road-load and full-throttle engine conditions.

Earlier window engines, L-head designs with quartz heads, never could be operated above 7 to 1 ratio, while today's valve-in-head engines

range from 8 to 1 to 10.5 to 1.

The piston crown on GM's engine is clear fused quartz with polished top and bottom surfaces for optical purposes. An angled mirror beneath the piston top reflects the combustion phenomena, and this image is photographed by a high-speed camera. A water-cooled transparent quartz-metal disc at the top of the cylinder admits light into the combustion chamber.

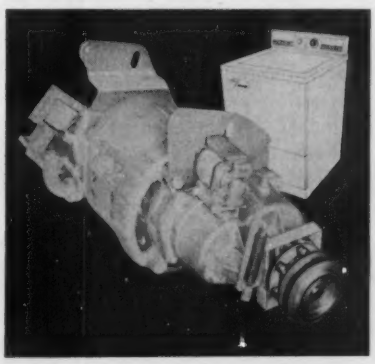
Basic difference between the GM "window" engine and its predecessors is that high-speed photos are taken through the top of the piston rather than through a "window" in its head—from the bottom up instead of from the top down.

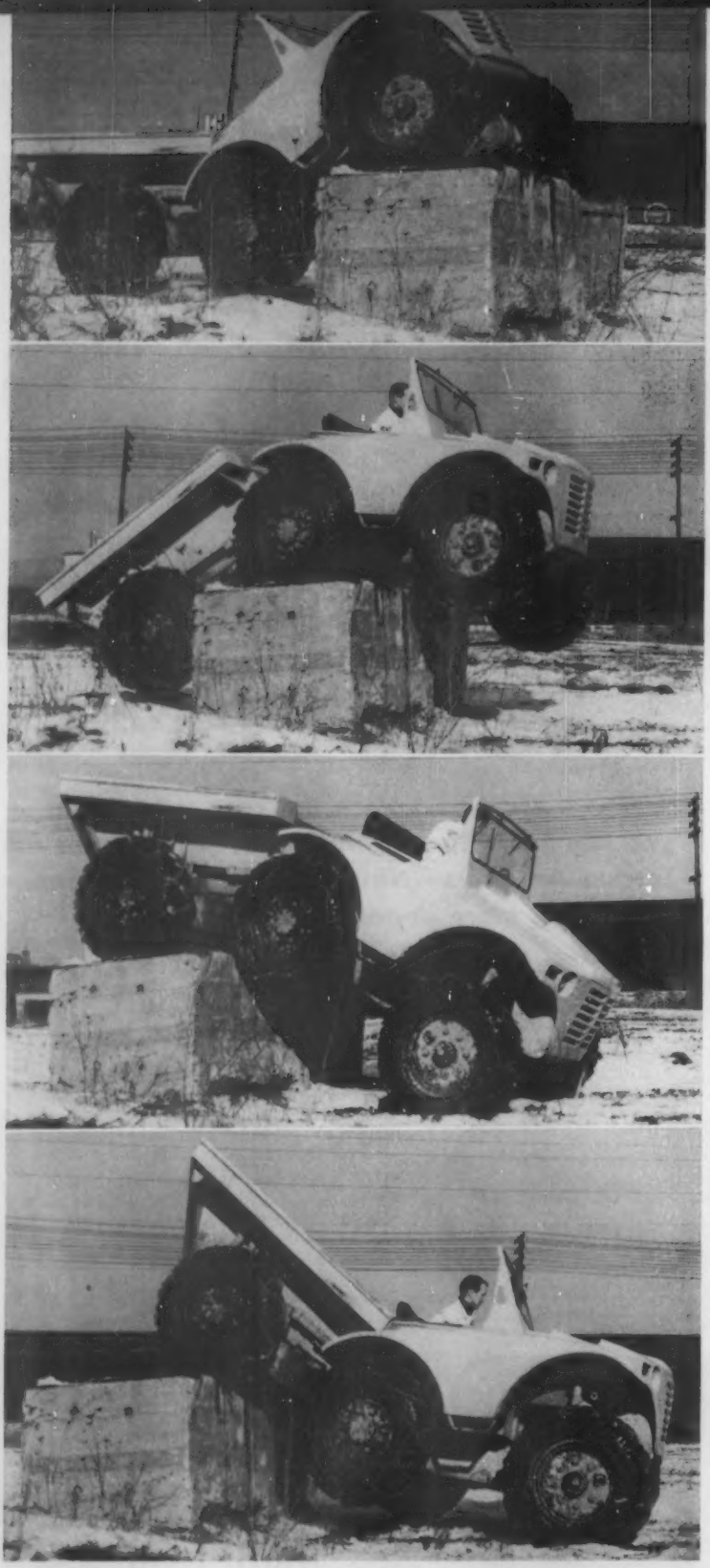
G-Force Activates New Speed Governor

BEDFORD, OHIO—New wrinkle in automatic washer design is the use of a speed-detecting device which: 1. Reduces vibration due to unbalance of the clothes load, 2. Reduces normal matting tendency of clothes.

Essentially a speed governor, the device is attached to the drive shaft of the appliance in a time-delay circuit. When centrifugal force exerted on the clothes during "spin dry" exceeds 1 g, the governor switch cuts out the appliance motor. This causes the machine to coast, allows clothes to fall away from the sides of the machine and become redistributed. When centrifugal force reduces to less than 1 g, the governor switch cuts in the motor to start the spin-dry sequence again.

After clothes have tumbled in this manner for 20 cycles, they are usually distributed in near-perfect balance, and are "fluffy," according to Torq Engineered Products Inc., Bedford, Ohio, designers of the device.





Shinnying up walls—one of Flex-Trac's best tricks—is largely a matter of hydraulic control. Front wheels are raised (retraction of articulation cylinders) and driven onto the wall; center wheels are then raised (extension of articulation cylinders) and the vehicle drives forward, assuming a perch on the wall. Hydraulic system is then engaged in "float" position, and Flex-Trac crawls down like an earthworm.

The

IT WON'T FLY, and it won't burrow. But on the surface of the earth, a unique Swiss-designed vehicle called the Flex-Trac is a veritable motorized mountain goat.

The rugged six-wheel truck demonstrated true Alpine instinct for coping with rough terrain by climbing 3-ft walls, fording streams, and crawling through mud, snow, and sand in a recent demonstration at Clark Equipment Co.'s Industrial Truck Div., Battle Creek, Mich. Clark is evaluating the vehicle, which was perfected by E. Meile, Schaffhausen, Switzerland, for commercial application in this country.

Flex-Trac's agility stems primarily from an unusual articulated construction which permits any one of its three pairs of wheels—all of which are driven—to be raised off the ground. The vehicle pivots vertically in the middle to assume a "swayback" position with the front or rear end higher than the center (depending on weight distribution), or an "arched-back" position with center wheels off the ground. It can hold either of these positions at an angle of about 30 deg.

This handy arrangement is further enhanced by a sort of variable suspension system: Four hydraulic cylinders, one at each of the front and rear wheels, can raise the front or rear of the vehicle's two-piece body, i.e., not only does the "frame" articulate, so does the body.

For highway travel (max speed: 56 mph), Flex-Trac conveniently assumes the arched-back position (center wheels up) to facilitate con-

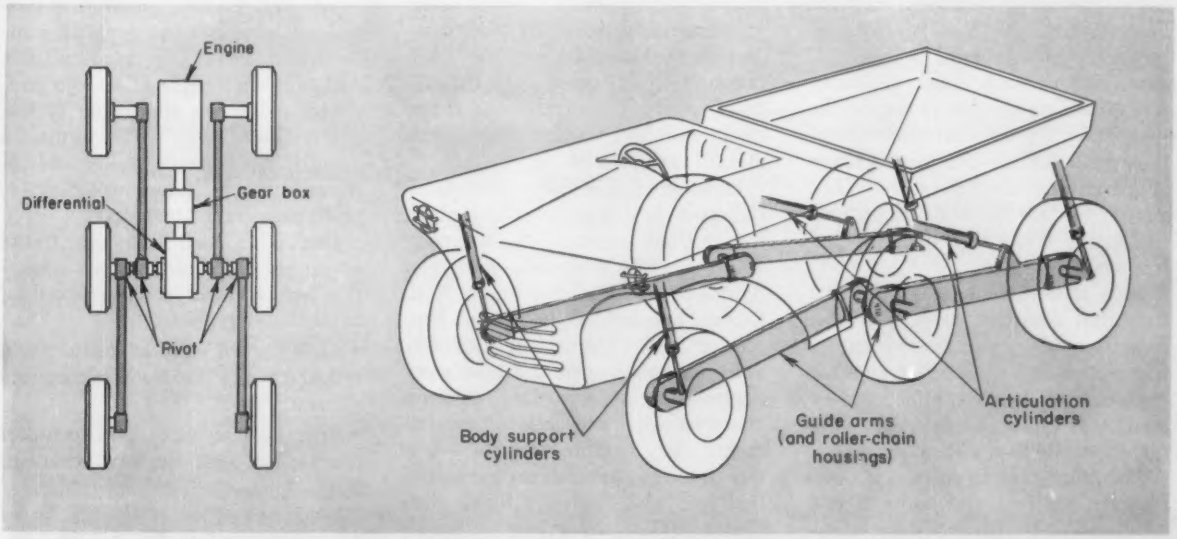
Double-Jointed Truck

ventional front-wheel steering. Off the highway, the vehicle may assume almost any position, depending on the obstacle at hand. With the main hydraulic control valve in "float" position, for example, the truck articulates freely—like a caterpillar—permitting all six wheels to maintain contact with the ground. On a lateral slope, one side of the vehicle can be articulated so that the body maintains a level posture.

Flex-Trac gains additional maneuverability by alternate methods of braking and power application. Braking action can be applied to all wheels simultaneously by a main brake pedal or to the left or right wheels through two brake levers. The machine can thus be steered like a tracked vehicle, or Flex-Trac can pivot in its own length when the operator puts the vehicle in swayback position and brakes a middle wheel. Similarly, power can be applied to all six wheels (differential locked out) or to the three wheels on either side.

For amphibious operations, two removable propellers are attached to a power takeoff unit on the transmission. Directional control in water is by front-wheel steering.

Clark is currently evaluating two Flex-Trac models at its Battle Creek proving grounds. One is rated at 1-ton capacity, weighs 3300 lb, and has an 86.5-in. wheelbase. It's powered by a 35-hp Volkswagen industrial engine. The other is rated at 2 tons, weighs 7100 lb, and has a 112-in. wheelbase. A standard Chevrolet six-cylinder engine (95 hp) powers the heavier model. Drive train in both models includes a foot-operated clutch and two gear boxes which provide 13 speeds forward, four in reverse.



Flex-Trac's *frame* consists of wheels and axles. Everything pivots around the center axle which carries a conventional differential. Guide arms extending from the center axle serve as housings for roller chains that drive the front and rear wheels. Articulation of the vehicle is controlled by a pair of double-acting cylinders mounted between the rear guide arms and front body section. Body sections also pivot about the center axle. The front two body support cylinders are interconnected, as are the rear two, permitting individual wheels to adjust to the terrain.

New feasible for powering or steering space craft, the pinch-plasma engine is no longer a laboratory curiosity. Engineers at Republic Aviation say that a 250-hp engine, based on the design of their highly successful laboratory model could be developed to power a 35,000-lb space vehicle.

The Plasma Engine: Flyable Prototype on the Way

FARMINGDALE, N. Y.—"Unexpected progress" has brought a practical space engine much closer to reality. A magnetic pinch-plasma engine, developed by Republic Aviation Corp., has completed 118 continuous hours of operation in the laboratory. When shut down (for electrode inspection) the engine was found to be in perfect working order.

This achievement marks the first time that scientists have been able to accomplish continuous cycling of the plasma "pinches" that give the engine its thrust. Republic's powerplant was cycled 30 times per minute, using 3000-v, 675-w current.

The pinch-plasma powerplant uses nitrogen for fuel and turns it into a plasma, a "fourth state of matter," in which the molecules are broken into electrons and positive ions. The plasma is compressed or "pinched" by a cylindrical magnetic field and shot out of the compression chamber at tremendous velocities. In comparison to the ion engine, the pinch plasma can operate on fuels that are more readily available and more easily handled. The plasma also attains greater thrust.

Because of Republic's laboratory successes, which came about much sooner than expected, the company will begin the immediate design of flyable prototypes, according to A. E. Kunen, manager of the Plasma-Propulsion Div. He said the remarkable performance of the laboratory engine—"It meets the optimum characteristics and power requirements for satellite control"—was due to a new, more direct method of fuel feed and "indestructible" electrodes. "And while our scientists were clearing up these major problem areas, other obstacles—overheating and erosion—were also overcome. All of the pieces fit into place at once," Mr. Kunen said.

Changes Due in Engineering Education

Curricula May Start In Junior High School

ANN ARBOR, MICH. — Important changes in engineering education, including greater centralization of college admissions, are foreseen by Prof. Lee E. Danielson (Ph. D.) of the University of Michigan.

In a book, just published, Danielson says the number of students attracted to science will exceed those interested in engineering, if present trends continue. And this will demand more formal means of selecting and training students in these fields, he adds.

"There will be increased testing and guidance at the junior high school level; specialized curricula will be developed at the same level. In short, vocational choice will be made earlier, and the student's future will be more directed. The characteristics of future engineers and scientists will depend more on the training they receive than on natural selection."

As for admissions, Danielson says, "It is not inconceivable that many engineering schools will co-operate in a nation-wide effort to fill their limited number of openings by following a procedure used by the American Medical Association. Colleges submit their academic requirements and student quotas to a central office. Students apply, are interviewed at one or more colleges, and state their order of college preference. Colleges state their preference of students. This information is fed into the central office and assignments are made according to preferences and openings."

Prof. Danielson lists four trends in engineering and science education which have become apparent at the college level:

- Inclusion of more advanced theoretical courses in mathematics and physics.
- Inclusion of more non-technical courses for engineers and scientists.
- Development of inter-departmental as well as inter-disciplinary courses.
- Extension of the normal four-year degree program to five years.

Danielson believes colleges should increase emphasis on application of

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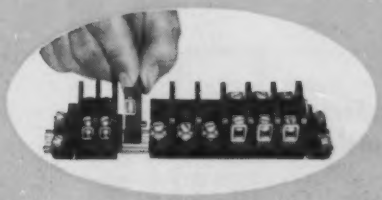

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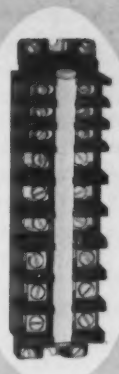

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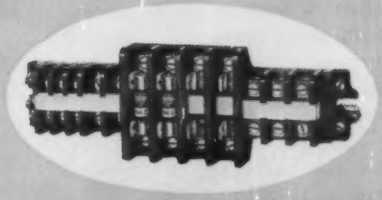

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knowledge by engineers and scientists. One way in which this might be done, he suggests, would be to increase the use of group research projects by college students. These would let students in diverse fields of interest handle a project with a single end product. Results could be presented in a written report to professors and business managers, and both academic and industrial criteria used to evaluate results.

Life Secrets Yield To Molecular Spotlight

Animal Cells Bombarded By Beams of Colored Light

LEMONT, ILL.—Beams of colored light from Argonne National Laboratory's new biological spectrograph are helping scientists clear up some of the secrets of life. They're focused on plant and animal cells to find out how "nature's clock" works.

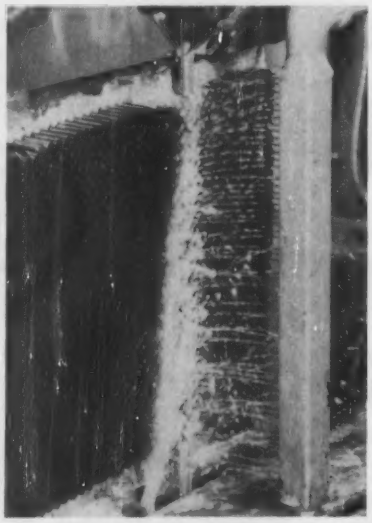
Recent evidence suggests chemical compounds within cells regulate such physical needs as desire for sleep. These compounds react differently to different colors of light.

Researchers at Argonne have found that animal "clocks" can be reset by exposing the animals to ultraviolet light. Chemical activities within the cells change. But these activities revert to normal when animals are exposed to visible violet. The pigments (light absorbers) haven't been isolated yet, says Dr. Charles F. Ehret, Biological and Medical Research Div., but we can prove they exist, and once we understand nature's time clocks we will have a way to probe mechanisms of wakefulness and sleepiness in humans.

Light at the other end of the visible spectrum (on the border between infrared and visible red) increases the damaging effects of x-rays on cells. Scientists believe this effect will have value if incorporated in x-ray therapeutic treatments, and filters that eliminate both red light and the near infrared might prove useful in increasing man's toleration for gamma radiation from nuclear reactors.

Pickup Truck Is Tailored to Small Load

Compact cargo vehicle, the Falcon Ranchero, has a payload capacity of 800 lb. The stylish, three-passenger truck is 189 in. long over-all; it has a 6-ft box. Claiming the usual economic advantages of a compact car, the Falcon Ranchero is powered by a 90-hp, six-cylinder engine. It also has bolt-on front fenders to facilitate repair or replacement, and a low load floor which saves 100 ft-lb of lifting every time a 500-lb load is placed in the truck. Ford feels that the junior-size Ranchero will fill a need of small businessmen who now operate trucks having greater capacity than is needed. According to Ford surveys, approximately 20 per cent of the average, half-ton pickup trucks in the country never haul more than a 750-lb load.



Arc "Saws" Honeycomb

Sparks instead of teeth cut through delicate honeycomb in a modified bandsaw developed by the DoAll Co., Des Plaines, Ill. An arc is sustained at the leading edge of a rapidly moving, endless band, while a spray of coolant localizes heating to the minute portion being cut at any instant. Stainless steel, or other hard-to-handle honeycomb material, can be cut at rates from 50 to 250 sq. in. per min, and a finish equivalent to that produced by grinding obtained.

Unionization of Technicians Called Threat to Engineering

NSPE Pledges Assistance in Resisting Union Organization

WASHINGTON—Concerned over the possibility that unionization of engineering technicians might hinder professional activities of engineers and even force the engineers themselves into collective bargaining, the National Society of Professional Engineers has adopted an official policy toward technicians' unions. Approved by the board of directors at the society's recent winter meeting, the policy states:

- NSPE should provide all possible assistance to engineering technicians who request help to prevent their unionization where it may affect the status of the professional engineers.
- In cases where professional engineers are closely related to technicians in conjunction with union organizing efforts, NSPE should assist both groups jointly.

NSPE emphasized its anti-union stand with the statement that "collective bargaining for professional engineers is in conflict with the basic principles of a professional individual."

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DIVISION OF CHARLES BRUNING CO., INC.

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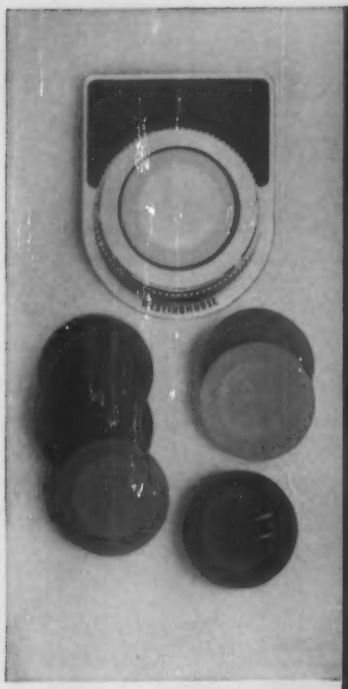
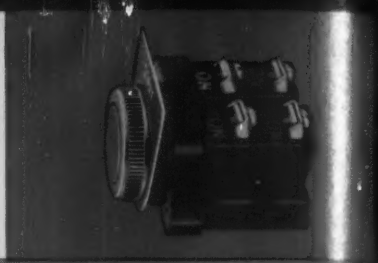
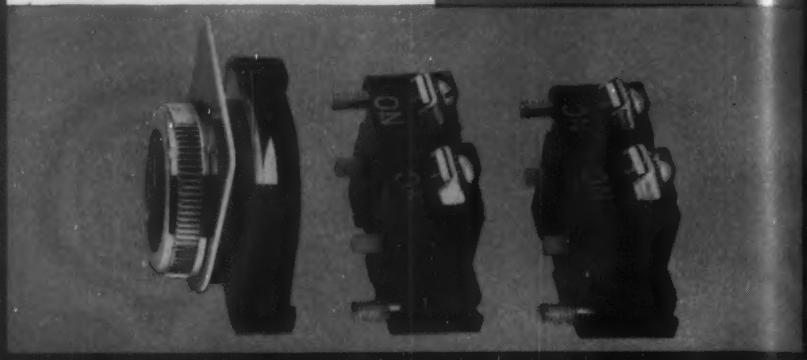


Easily snapped-on plastic caps come in seven colors—red, green, blue, yellow, gray, tan and black—for quick color coding of a push-button bank.

Assembled units (right) permit multiple contactors in limited space. As many as six contact blocks can be coupled to a single pushbutton.

Westinghouse Flush Pushbutton (below) with contact blocks. Notice how one fits directly behind the other. Stacking permits controlling many circuits with one button.





YOU GET...
TOTAL DESIGN FLEXIBILITY IN THE WESTINGHOUSE FLUSH PUSHBUTTON

circuit flexibility—unique spacesaving design permits as many as six contact blocks to be stacked one behind the other. You operate all circuits with one push of a button . . . a big help when multiple operations are necessary.

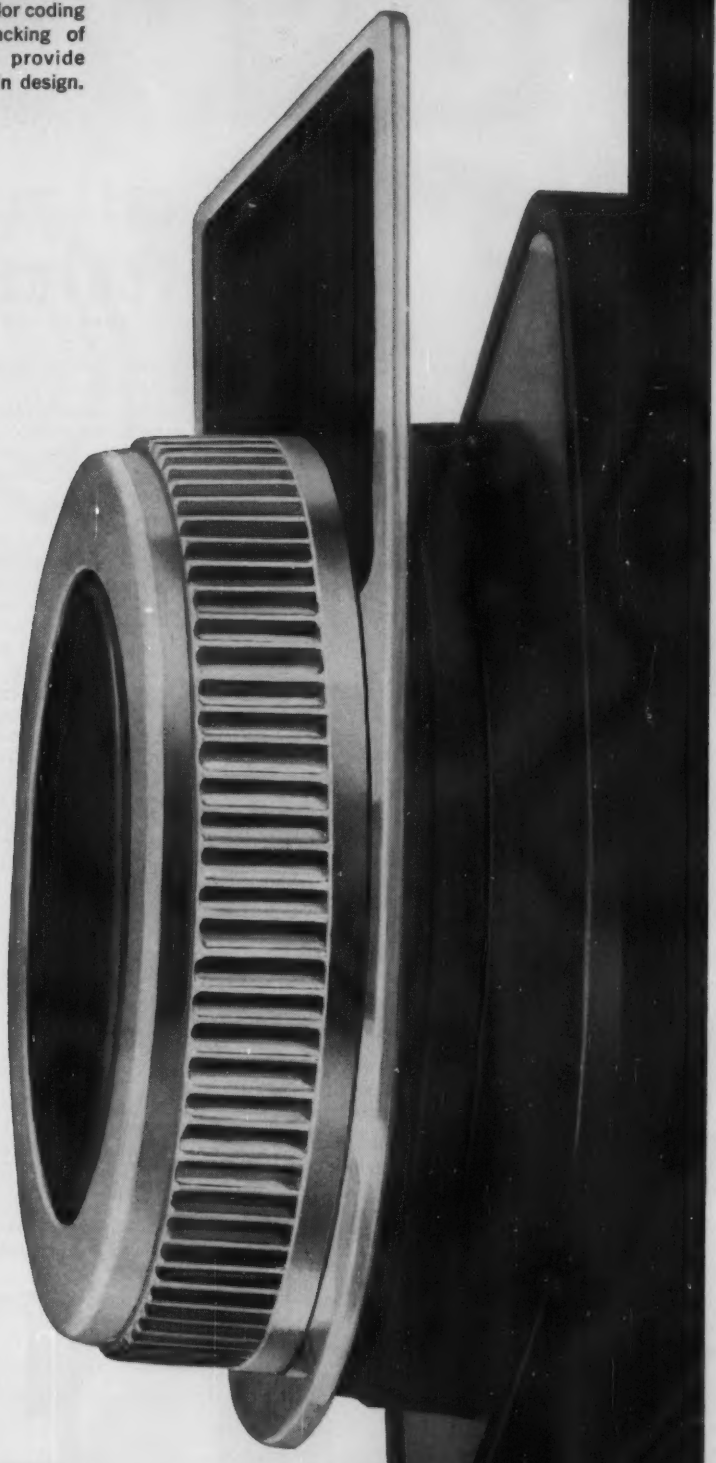
color flexibility—interchangeable chemical-resistant plastic caps come in seven colors: red, green, blue, yellow, tan, gray and black. Choose the best pushbutton for your design and color code it. Permits programming of manual operation using only one model.

function flexibility—choose from a wide range of operators to suit any use. Standard units available include flush head, mushroom head, extended head, selector switches, push-to-test indicating lights and a host of others.

When your design calls for pushbuttons, you'll find what you need in Westinghouse stock. Call your nearest Westinghouse representative, or write Westinghouse Electric Corporation, Standard Controls Div., Beaver, Pennsylvania. J-30313

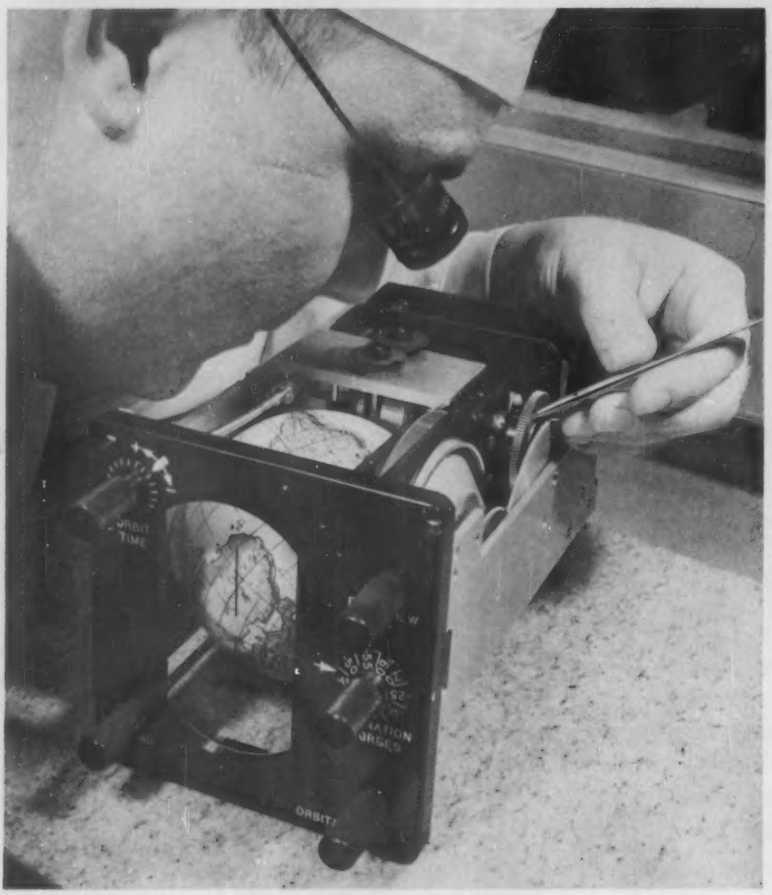
YOU CAN BE SURE...IF IT'S Westinghouse

The Westinghouse Flush Pushbutton . . . color coding and multiple stacking of contact blocks provide greater flexibility in design.



Circle 418 on Page 19

Private World for Mercury Astronauts



Mechanically powered for independent functioning, the Earth Path Indicator will permit Mercury astronauts to make critical decisions concerning navigation in the event their capsule is lost by ground tracking stations.

MINNEAPOLIS—A device that will enable the nation's first orbiting astronaut to see his position over the earth at all times may turn out to be one of the most vital instruments stowed aboard the Project Mercury space capsule. Called an Earth Path Indicator, the device will be the prime source of position information if the capsule loses contact with ground tracking stations. It would enable the astronaut to fire the capsule's retro rockets at the proper time prior to re-entry—a critical operation, since the capsule is designed to land in water only.

The 4-in. diameter globe inside the indicator displays longitude, latitude, continents, topography, and major cities. Calibrated lines on the window of the instrument give the astronaut his position over the earth and his landing area some 3000 to 4000 miles from that position. The device has four adjustments to correspond to the capsule's orbit path and speed: Earth's polar east-west rotation; the capsule's position in orbit path; inclination to the equator; and orbit period, or time. Inclination adjusts from 28 to 40 degrees; orbit period, from 5200 to 5400 seconds (approximately 1½ hours).

Like the earth, the globe revolves around a north-south axis; at the same time it revolves around an axis perpendicular to the orbit plane to duplicate the capsule's travel. Complexity of the instrument results from the fact that the globe revolves in two directions simultaneously and at the same time can be adjusted to any orbit path.

Circle 419 on Page 19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Call Western Union Operator 25
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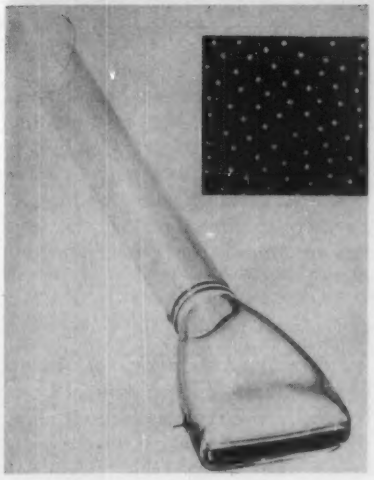


Cathode-Ray Bulb Developed For High-Speed Printing

Wire conductors—35,000 of them—embedded in the face of a new cathode-ray bulb make possible electronic-printing speeds of 20,000 characters per sec. The conductors measure 0.001-in. diam and are spaced about 0.003-in. apart (magnified in the insert). They transfer electrostatic charge from an electron beam to moving paper. The bulb was developed by Corning Glass Works, Corning, N. Y.

Meetings and Shows

April 11-13—

Fourth Conference on Manufacturing Automation to be held at Purdue University, Lafayette, Ind. Conference is sponsored by Purdue and *Automation* magazine. Further information can be obtained from K. E. Glancy, Div. of Adult Education, Purdue University.

April 12-13—

American Institute of Electrical Engineers. Technical Conference on Electrification of Materials Handling Equipment to be held at the Hotel Sheraton, Philadelphia. Further information is available from AIEE headquarters, 33 W. 39th St., New York 18, N. Y.

April 12-13—

Institute of Radio Engineers. 14th Annual Spring Technical Meeting to be held in conjunction with the American Rocket Society at the Hotel Alms, Cincinnati. Further information is available from IRE, 1 E. 79th St., New York 21, N. Y.

April 18-19—

Third Annual Conference on Automatic Techniques to be held at the Sheraton-Cleveland Hotel, Cleveland. Sponsors are American Institute of Electrical Engineers, American Society of Mechanical Engineers, and Institute of Radio Engineers. Additional information is available from J. H. McRainey, Room 530, 1213 W. Third St., Cleveland 13, Ohio.

April 19-21—

American Society of Lubrication Engineers. Annual Meeting and Exhibit to be held at the Netherland-Hilton Hotel, Cincinnati. Additional information is available from ASLE headquarters, 84 E. Randolph St., Chicago 1, Ill.

April 19-21—

National Microfilm Association. Ninth Annual Convention to be held at the Hotel Sheraton-Hilton, New York. Further information can be obtained from C. Peter McColough, Haloid Xerox Inc., Rochester 3, N. Y.

April 20-22—

Institute of the Aeronautical Sciences. National Symposium on Manned Space Stations to be held at the Ambassador Hotel, Los Angeles. Further information can be obtained from IAS headquarters, 2 E. 64th St., New York 21, N. Y.

April 21-28—

American Society of Tool and Manufacturing Engineers. Tool Show to be held in the Artillery Armory, Detroit. Further information can be obtained from society headquarters, 10700 Puritan Ave., Detroit 38, Mich.

April 25-29—

American Welding Society. 41st Annual Convention and Welding Exposition to be held in Los Angeles. Technical sessions will be at the Biltmore Hotel; the show, at the Great Western Exhibit Center, April 26-28. Further information is available from AWS, 33 W. 39th St., New York 18, N. Y.

April 27-28—

National Conference on Space-Age Materials to be held at the Sheraton-Gibson Hotel, Cincinnati. Sponsor is the Cincinnati Chapter of the American Society for Metals. Further information can be obtained from ASM headquarters, Metals Park, Novelty, Ohio.

May 3-5—

National Association of Relay Manufacturers. Eighth Annual Conference on Electromagnetic Relays to be held at Oklahoma State University, Stillwater, Okla. Additional information is available from Prof. Charles F. Cameron, P. O. Box 6, Stillwater, Okla.

May 3-5—

Western Joint Computer Conference to be held at the Jack Tar Hotel, San Francisco. Sponsors are Institute of Radio Engineers, American Institute of Electrical Engineers, and Association for Computing Machinery. Further information can be obtained from William C. Estler, 965 Lincoln Ave., Palo Alto, Calif.

May 7-13—

Society of the Plastics Industry Inc. National Conference and Annual Meeting to be held on the *Queen of Bermuda.* Further information can be obtained from SPI headquarters, 250 Park Ave., New York 17, N. Y.

May 9-11—

National Fluid Power Association. Spring Meeting to be held at the Grand Hotel, Point Clear, Ala. Additional information is available from Barrett Rogers, executive secretary of NFPA, 5595 N. Hollywood Ave., Milwaukee 17, Wis.

May 9-12—

Instrument Society of America. Instrument-Automation Conference and Exhibit to be held at the Civic Auditorium and Brooks Hall, San Francisco. Further information can be obtained from ISA, 313 Sixth Ave., Pittsburgh 22, Pa.

May 9-13—

American Society for Metals. Second Southwestern Metal Exposition

and Congress to be held at the Sheraton-Dallas Hotel and State Fair Park, Dallas. Additional information is available from ASM, Metals Park, Novelty, Ohio.

May 9-13—

American Foundrymen's Society. Castings Congress and Exposition to be held in Convention Hall, Philadelphia. Additional information is available from AFS headquarters, Golf and Wolf Roads, Des Plaines, Ill.

May 9-13—

Society of Photographic Scientists and Engineers. Annual Conference to be held at the Miramar Hotel, Los Angeles. Additional information can be obtained from the society, Box 1609 Main Post Office, Washington, D. C.

May 11-14—

American Helicopter Society. 16th Annual National Forum to be held at the Sheraton Park Hotel, Washington, D. C. Further information can be obtained from AHS executive secretary Harry M. Lounsbury, 2 E. 64th St., New York 21, N. Y.

May 17-19—

American Society of Mechanical Engineers. Production Engineering Conference to be held at the Hotel Schroeder, Milwaukee. Further information is available from Meetings Dept., ASME, 29 W. 39th St., New York 18, N. Y.

May 22-26—

American Society of Mechanical Engineers. Oil and Gas Power Conference and Exhibit to be held at the Muehlebach Hotel, Kansas City, Mo. Additional information can be obtained from Meetings Dept., ASME, 29 W. 39th St., New York 18, N. Y.

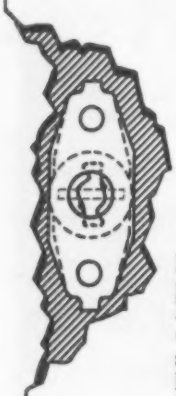
May 23-26—

Design Engineering Show and Conference to be held at the Coliseum, New York. Conference is sponsored by the Machine Design Div. of ASME. Further information can be obtained from Clapp & Poliak, 341 Madison Ave., New York 17, N. Y.

Circle 423 on Page 19

For quick access and closure . . .

LION ¼ TURN OPEN ¼ TURN CLOSED FASTENERS



NO. 5 STUD

RETAINER

RECEPTACLE

Hinged and completely removable panels are secured reliably by unique Lion Fasteners which are opened or closed by a quick ¼ turn. These mil spec (MIL-F 5591A-ASG) fasteners have a high strength to weight ratio, lock smoothly with a positive grip, withstand vibration.

ALIGNMENT NOT CRITICAL

Both stud and receptacle "float" to accommodate misalignment. The hole, which retains the stud, is twice as large as the stud cross-section. This permits a float of .070 in all directions. The leaf spring receptacle also floats to accommodate stud positions.

WIDE VARIATIONS IN STACK HEIGHT

Total sheet thickness may vary as much as +.035 or −.015 without affecting operation. A Lion stud, specified for .160 total thickness, for example, will accommodate any stack height between .195 and .145.

SWAGED-NOSE STUD

Extra strength and smooth operation are made possible by the swaged-nose design. All the metal in the stud goes to work. There are no thin crosspins, holes or milled slots to weaken the cross-section. Case hardening is further assurance of long, trouble-free service.

WIDE VARIETY

Lion Fasteners are available in 3 sizes —No. 5, No. 2, and Miniature. An assortment of head styles is supplied —oval, flush, wing, ring, notched or knurled—according to individual requirements.

FREE!
FASTENER HANDBOOK

Send for your free copy of Southco Fastener Handbook No. 9. Gives complete engineering data on Lion Fasteners and other special fasteners. Write to Southco Division, South Chester Corporation, 237 Industrial Highway, Lester, Pennsylvania.

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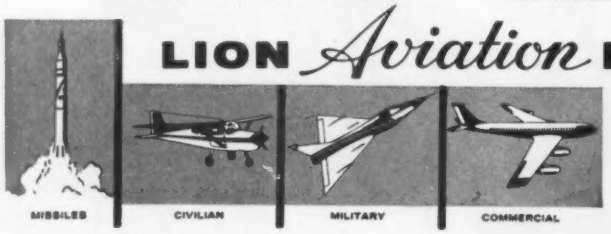


LION *Aviation* FASTENERS

one of the SOUTHCO LION FASTENERS

How Keystone QUALIFIES

as the leading independent producer of POWDER METAL PARTS

(over 150,000,000 of them annually)

We're told, often enough, that "There's a difference in dealing with Keystone."

In looking over some of the reasons-why, it occurs to us that because we were pioneers in powder metallurgy, perhaps we do have a special kind of perspective about our work. Over and beyond the essentials of a sound organization and production facilities to meet your requirements for almost any quantity of parts . . . on time, and at low cost . . . we have qualifications that are inseparable from the Keystone way of doing things.

One of them is *alert interest* in your problems (we learn more that way). Another: *creative approach* to your designs—which keeps us flexible. And one of special importance: *objective evaluation* —if application is unsound, we're frank to say so.

Perhaps we should conclude with *progressiveness.* Facts are, Keystone was first to produce commercially powder metal parts of alloy and stainless steels; first in the field to offer lower-than-commercial tolerance bearings, and first to provide corrosion-resistant finishes on iron powder parts.

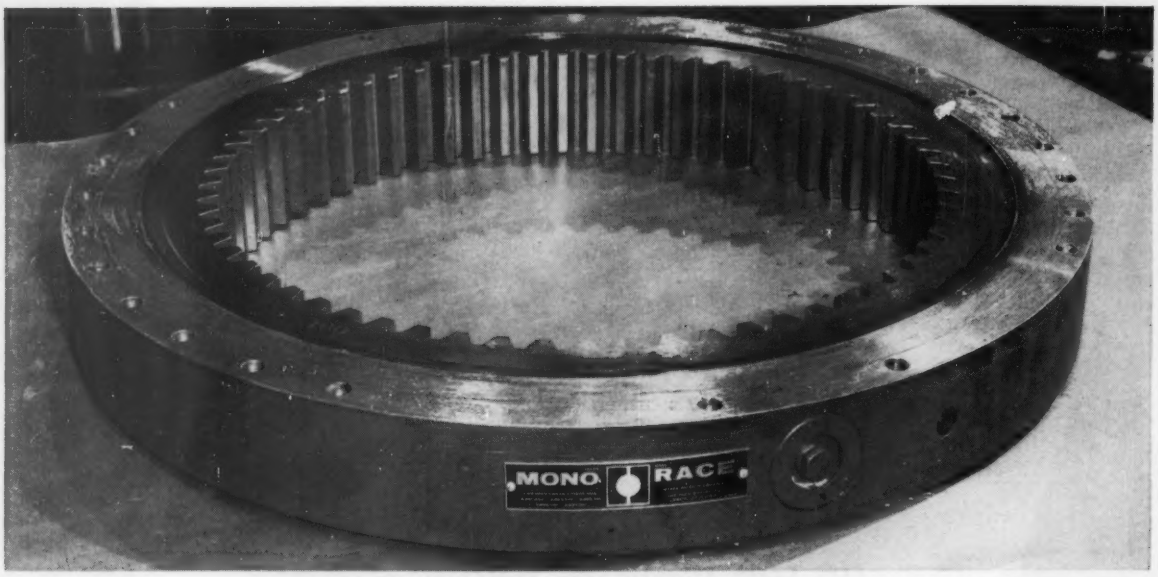
For these and other reasons, a great many people turn to Keystone for the powder metal parts their businesses require. It's easily possible that you'd enjoy having us work for you, too. Write, and let's talk it over.

Keystone CARBON COMPANY

ST. MARYS, PA.

POWDERED METAL PARTS DIVISION

Circle 425 on Page 19



Mono-Race is made up of a full circle of hardened steel balls interlocking two races made of rolled forged rings. The balls take all vertical, horizontal and radial loads and thrusts. Gearing may be on outside (below) or inside (above) of the race.

NEW

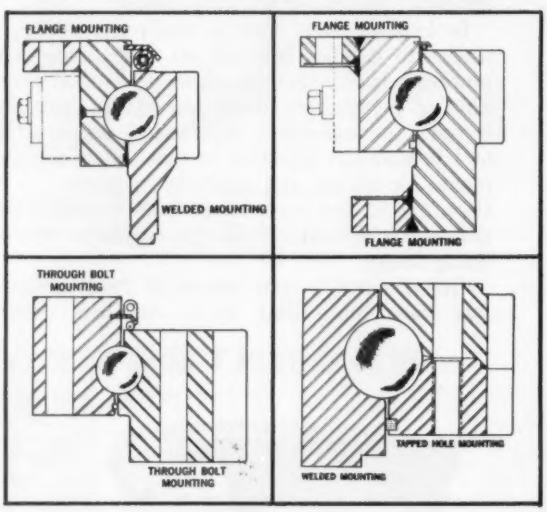
MONO-RACE large ball bearing connections for equipment that rotates under load

Does two jobs in one – a load bearing member . . . and an outstanding connection that reduces the wear, maintenance and adjustment of center pin and roller designs.

Precision built to your specifications. Mono-Race is completely designed and built at the Lorain plant. All operations – grinding the races, hardening, machining and gear cutting – are under rigid production control.

Design field tested for 10 years. Mono-Race design is similar to the famous "Shear-Ball" connection used successfully on Lorain shovels and cranes for over 10 years. "Shear-Ball" mounting is guaranteed for 10 years against failure to function in normal use and service.

Mono-Race is available in 2-ft. to 12-ft. diameters. Ball sizes from 1-in. to 3½-in. Write direct for details.



MONO RACE DIVISION

THE THEW SHOVEL COMPANY, LORAIN, OHIO

Circle 426 on Page 19

Copper Alloy Bulletin

BRIDGEPORT BRASS COMPANY

new BRIDGEPORT NIRONZE® 635 gives 90,000 psi yield strength

90,000 psi Yield Strength Obtained with New Age-Hardenable Copper-Nickel-Silicon Alloy

Bridgeport Nironze 635, an age-hardenable copper-nickel-silicon alloy, combines excellent cold-working properties with high tensile and very high yield strengths, good electrical conductivity, excellent general and stress-corrosion resistance. Supplied in the solution-treated and drawn condition, Nironze 635 offers exceptional cold-working properties. A low-temperature heat treatment, following additional cold-work age, hardens this alloy to produce tensile strengths of 100,000 psi, yield strengths of 85,000 psi and improved electrical conductivity of a minimum of 35% IACS.

Easily Cold-Formed... Machined

The excellent cold-working properties of Nironze 635 in the *solution-treated and drawn* condition allow such severe cold work as upsetting, cold-heading, roll-threading, bending, forming or similar operations to be carried out with ease. Heat treatment following this cold-work age-hardens this alloy to produce maximum tensile and yield strengths.

Nironze 635 in the *solution-treated-drawn-aged* condition has a machinability about 30% of free-cutting brass rod, thereby making it possible to carry out such conventional machining operations as sawing, grinding, turning, milling or similar operations.

Maximum cold-work may be performed on Nironze 635 in the *solution-treated* or soft condition. In order to obtain highest possible physical properties, this alloy must be cold-worked from 50-80% before aging.

Typical connectors which benefit from high yield strength of NIRONZE 635.

Proved by Performance in These Applications

Cold-headed bolts and fasteners used in pole line hardware, switch gear, wire connectors, neon signs, railway equipment, exposed electrical parts and structural supports, marine hardware and fittings can all use Nironze 635 to advantage. The new alloy's unique combination of high yield and tensile strengths, good conductivity and high corrosion resistance provides design and production advantages never before offered by a silicon bronze.

Test a Sample Now

Nironze 635 has been thoroughly evaluated in the laboratory and in the field to insure the high quality and top performance common to all Bridgeport alloys. To get your test samples and full technical information, call your nearest Bridgeport Sales Office. Or write us direct. Dept. 4304.

Nironze 635 is presently available as rod or wire, supplied in the solution-treated, solution-treated and drawn, and solution-treated, drawn and aged.

NIRONZE PHYSICAL PROPERTIES

Density	0.320 lb/in.³
Color Red	similar to copper
Thermal Expansion	8.9 x 10⁻⁶/°F
Melting Point	1990°F
Nominal Composition:	
Copper	97.5%
Nickel	1.9%
Silicon	0.6%
Total	100.0%
Electrical Conductivity, % IACS	
Cold-drawn and aged	30%
Cold-drawn	15%

MECHANICAL PROPERTIES (Nominal)

Form	Condition	Tensile Strength psi	Yield Strength psi	Elongation % (4D)	Contraction of Area %	Rockwell B Hardness	0/0 IACS
Rod and Wire	Solution-Treated	40,000	12,000	50	90	7	24
	Solution-Treated, Aged	88,000	70,000	12	20	86	43
	S.T. Drawn 50%	65,000	62,000	18	87	67	22
	S.T. Drawn 50%, Aged	100,000	90,000	12	25	95	42
	S.T. Drawn 80%	70,000	65,000	15	85	73	22
	S.T. Drawn 80%, Aged	103,000	97,000	17	62	96	39

COMPARATIVE RATINGS OF NIRONZE 635 vs STANDARD SILICON BRONZES

	Physical Properties			Fabrication Properties			Mechanical Properties		
	Electrical Conductivity (Annealed) % IACS	Melting Point Liquidus °F	Density lb/in.³	Cold Workability	Machinability Rating %	Annealing Temp. °F	Tensile Strength psi	Yield Strength psi	Rockwell B Hardness
NIRONZE 635	*35	1990	0.320	Excellent	*30	**850-900	100,000	85,000	95
High Silicon Bronze (A)	7	1880	0.308	Excellent	30	900-1300	108,000	60,000	95
Low Silicon Bronze (B)	9	1940	0.316	Excellent	30	900-1250	90,000	67,000	90

*The term "Nironze" is a registered trade-mark of the Bridgeport Brass Company

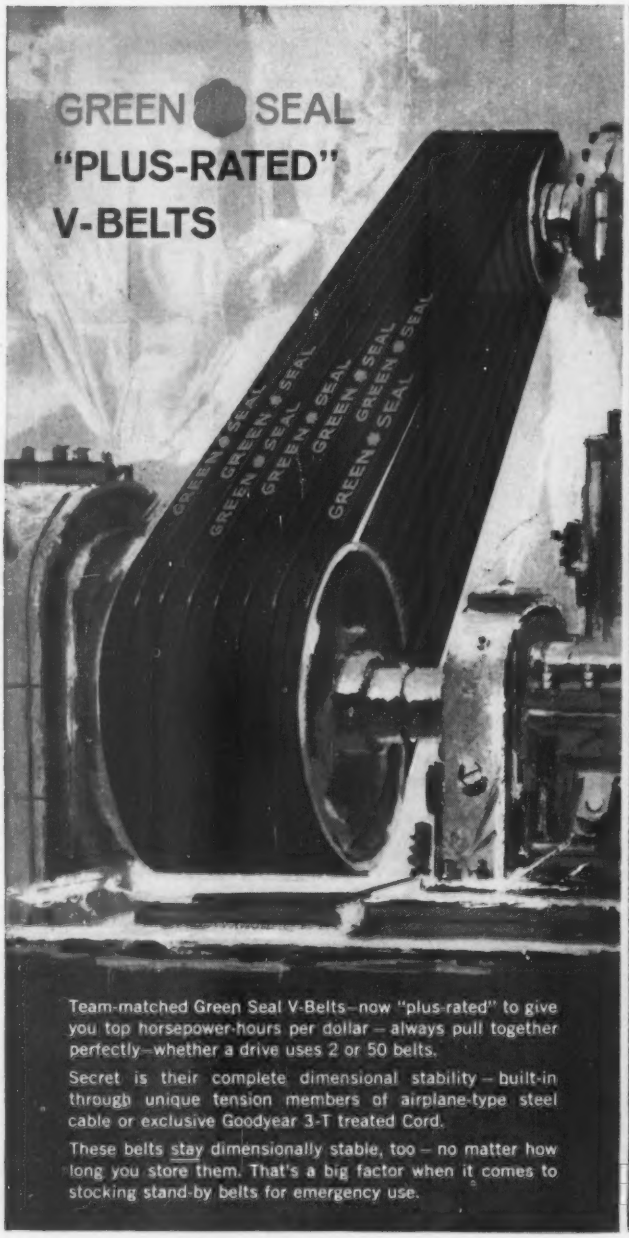
*Drawn and aged **Aging temperature

BRIDGEPORT BRASS COMPANY

Bridgeport 2, Connecticut • Sales Offices in Principal Cities

Specialists in Metals from Aluminum to Zirconium

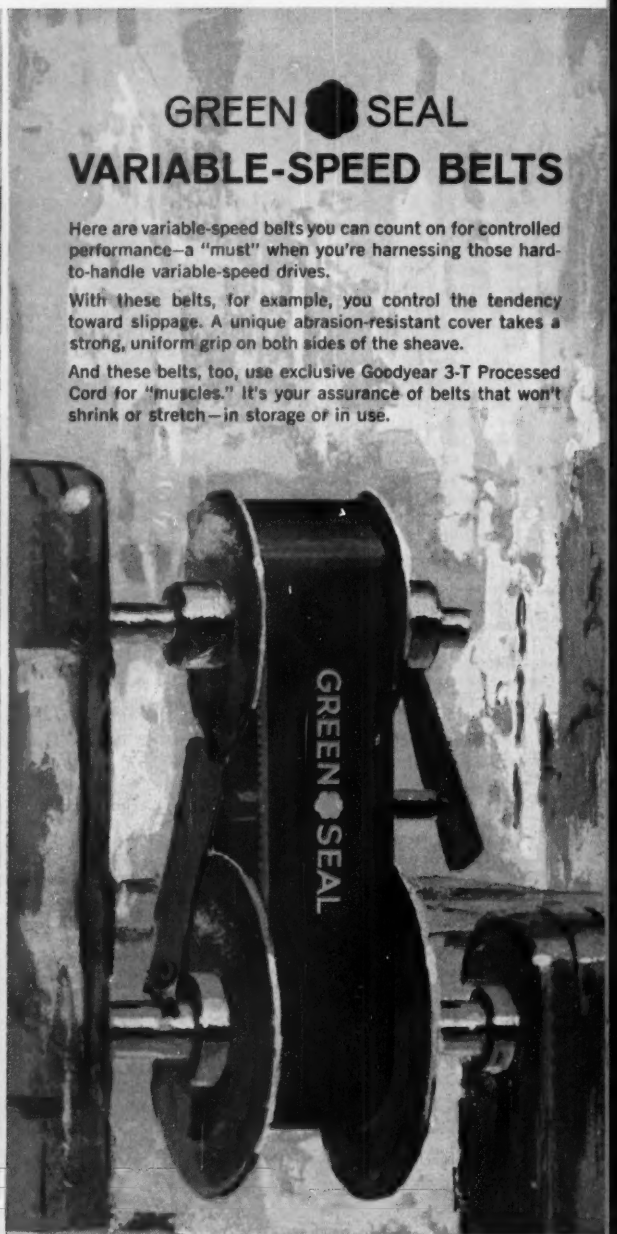
to beat all your belting problems...



Team-matched Green Seal V-Belts—now "plus-rated" to give you top horsepower-hours per dollar—always pull together perfectly—whether a drive uses 2 or 50 belts.

Secret is their complete dimensional stability—built-in through unique tension members of airplane-type steel cable or exclusive Goodyear 3-T treated Cord.

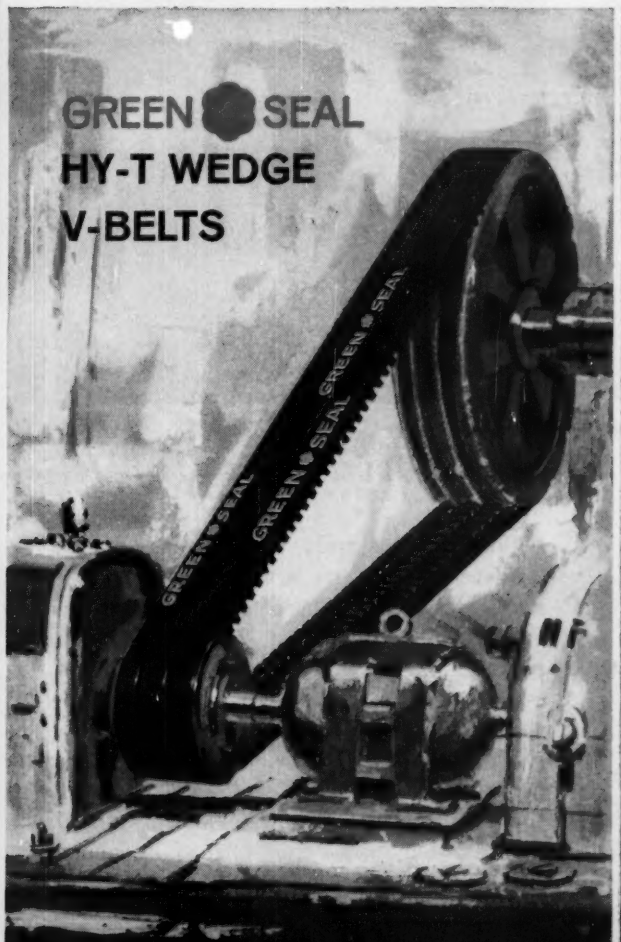
These belts stay dimensionally stable, too—no matter how long you store them. That's a big factor when it comes to stocking stand-by belts for emergency use.



NO MATTER WHAT YOU'RE BELTING—OR WHAT TYPE BELT IT CALLS FOR—YOU CAN COUNT ON A GOODYEAR BELT FOR MAXIMUM, TROUBLE-FREE HOURS AT MINIMUM COST. JUST CONTACT THE

THE BIG NAME IN V-BELTS: **GOODYEAR**

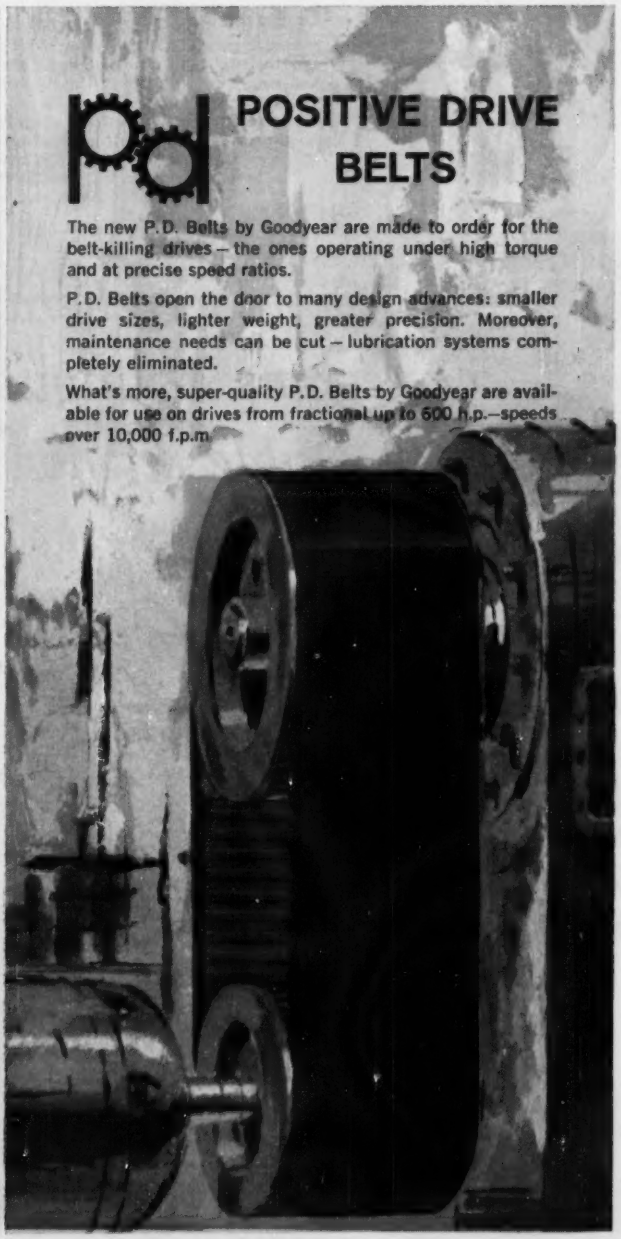
go down the line with Goodyear



With these new, "wedge" V-Belts, you can belt the same horsepower on drives as much as 50% smaller – saving as much as 20% in drive costs.

You see, the new HY-T WEDGE design eliminates excess "fat" without the sacrifice of strength. And HY-T WEDGE V-Belts are made in 3 different cross sections to meet all requirements. All 3 are oil-resistant and static-conducting at no extra cost.

And they're all Green Seal quality – the only wedge-type V-Belts offering you 3-T construction for perfect team performance.



POSITIVE DRIVE BELTS

The new P.D. Belts by Goodyear are made to order for the belt-killing drives – the ones operating under high torque and at precise speed ratios.

P.D. Belts open the door to many design advances: smaller drive sizes, lighter weight, greater precision. Moreover, maintenance needs can be cut – lubrication systems completely eliminated.

What's more, super-quality P.D. Belts by Goodyear are available for use on drives from fractional up to 600 h.p.–speeds over 10,000 f.p.m.

G.T.M.–GOODYEAR TECHNICAL MAN–THROUGH YOUR GOODYEAR DISTRIBUTOR. OR WRITE: GOODYEAR, INDUSTRIAL PRODUCTS DIVISION, LINCOLN 2, NEBRASKA, OR AKRON 16, OHIO.

GOODYEAR

THE GREATEST NAME IN RUBBER

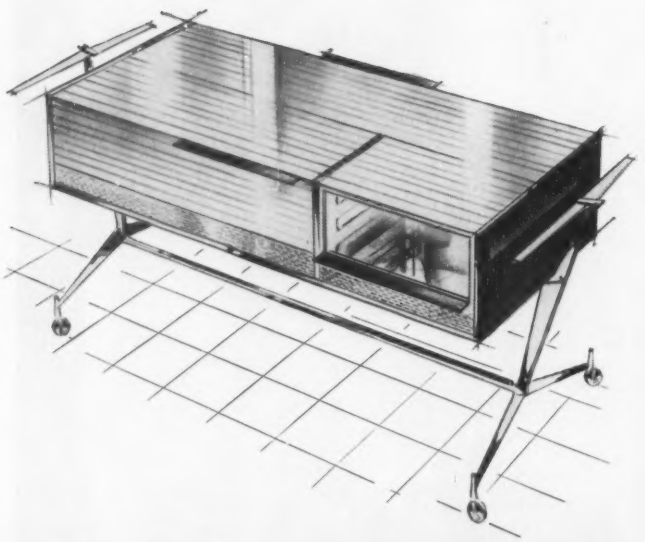
Green Seal, HY-T WEDGE, P.D.–T. M.'s The Goodyear Tire & Rubber Company, Akron, Ohio

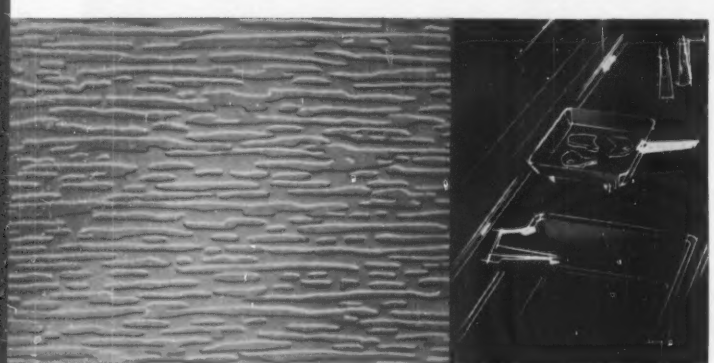
Circle 428 on Page 19

Carl Sundberg and Montgomery Ferar joined fortunes in 1934 and since have had a great influence on improving the design of mass-produced consumer and industrial products.

One of the largest of the nation's recognized design firms, they have put their talents to work on hundreds of nationally known products ranging from pencil clips to heavy-duty motor trucks and electronic computers. Recognized leaders in the design of electrical appliances, they are permanently retained by many of America's best known appliance manufacturers.

Sundberg-Ferar designs a unique, portable kitchen caddy with wonderful...





• Sharonart® is truly the designer's metal. Evidence of this fact is this modern kitchen caddy designed in Sharonart® by Sundberg-Ferar, one of the oldest, largest and most successful industrial design firms in the United States.

The portable caddy permits complete cooking facilities anywhere inside or outside of the home. To make sure it would be able to absorb the punishment of daily use, yet stay bright and clean, Sundberg-Ferar designed the cabinet and working areas in patterns of Sharonart® Stainless. Wood grain Sharonart® steel panels at each end give the furniture-look that blends with other home furnishings.

The textured beauty of Sharonart® can be produced in an almost limitless number of patterns. This permits easy model changing. It's easy to clean and will not show wear. It can be painted, plated, or vinyl coated with beautiful results. Is it any wonder that more and more of the leading designers are turning to modern Sharonart® for modern product design? *Sharon Steel Corporation, Sharon, Pa.*

About the portable kitchen caddy: This is a design only, produced to show the tremendous utility of Sharonart®. All the seemingly built-in utensils are self-energized, and can be plugged into any electrical outlet as well as being used with the caddy itself. The rotisserie has vertical elements that can be moved closer together for the smokeless vertical broiling of steaks. All utensils are removable and can be used at the dinner table for gourmet cooking. Plenty of workspace is provided for complete meal preparation right at the caddy.

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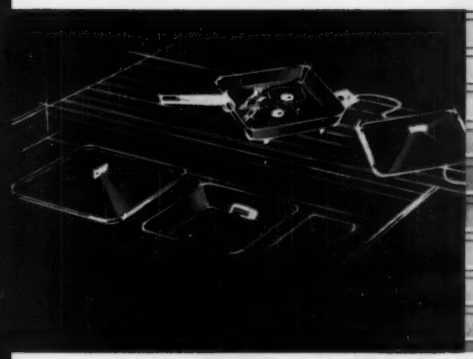
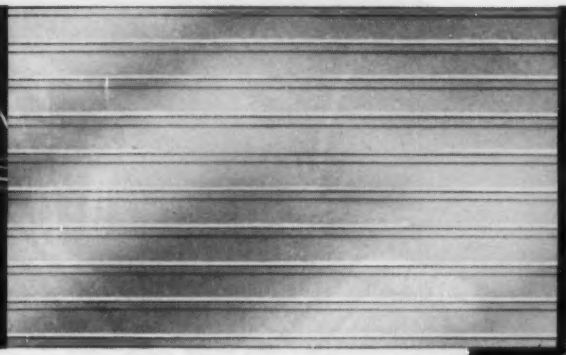
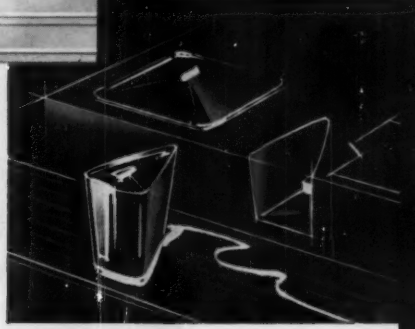




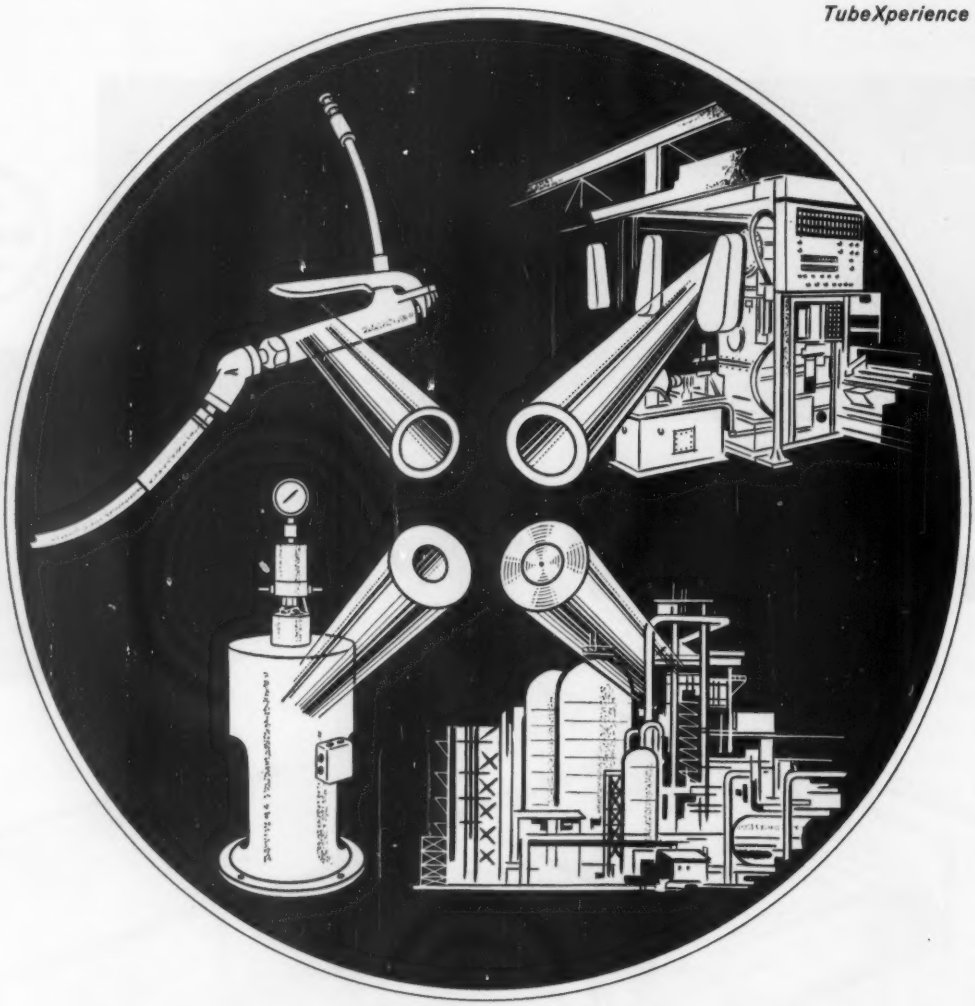
Steel



SHARONART®

SHARON *Quality* STEEL

SHARONSTEEL



Superior tubing makes pressures behave

whether 125, 5000, 30,000 or 100,000 psi

Superior small-diameter tubing makes pressures behave whether low, medium, high or super. Superior pressure tubing can be roughly divided into two groups: commercial pressure tubing for use in a range up to 20,000 psi; premium super pressure tubing to handle pressures from 15,000 to 100,000 psi. Both ranges can be handled effectively by a number of different analyses, depending on service requirements. Typical applications for Superior general-purpose pressure tubing include pressure tools, machine tools, heat exchangers and condensers. Superior super-pressure tubing is found in hydrogenation process equipment, high-pressure autoclaves, and pilot plant installations in chemical and oil refining plants.

All Superior pressure tubing offers many advantages. It helps prevent critical failures and downtime. It assures long service life, high fatigue strength, excellent corrosion and chemical resistance. In the range from 15,000 to 100,000 psi, Superior super-pressure tubing is a premium product. It is produced from specially selected raw materials. Inside surfaces are conditioned to remove fissures and other defects. During processing, special degreasing operations are performed, and the inside diameters are conditioned to insure a clear, smooth surface. Two types are available: a single wall mechanical tubing and a double wall, or composite unit, made from two thinner tubes. It is produced in an annealed condition and in ⅛ hard temper, and to mechanical properties specified by the customer. All Superior pressure tubing is 100% hydrostatically tested to recommended working pressures, and rigidly inspected for defects.

We can probably help you with any tubing problem that may confront you . . . in pressure, super-pressure or other applications. Contact us and feel no obligation. Superior Tube Company, 2010 Germantown Ave., Norristown, Pa.

Superior Tube

The big name in small tubing

NORRISTOWN, PA.

All analyses .010 in. to ⅜ in. OD—certain analyses in light walls up to 2½ in. OD

West Coast: Pacific Tube Company, Los Angeles, California • FIRST STEEL TUBE MILL IN THE WEST

For each $1,000 you spend for fasteners, you're probably investing AN EXTRA $4,000* to install those same fasteners! Shakeproof has found the most effective way to reduce this major part of assembly cost . . . on-the-line engineering.

CUT YOUR FASTENING COST...

where it matters most!

WHAT IS SHAKEPROOF ON-THE-LINE ENGINEERING?

In *your* plant, out on the line, a Shakeproof idea engineer carefully studies an assembly operation. By watching, asking and listening, he uncovers fastening problems or areas where product performance can be improved through improved fastening techniques. He then applies his specialized knowledge of fasteners and assembly methods to simplify and improve both the product and assembly operation. He might recommend one of the broad line of Shakeproof fasteners to solve the problem or to increase product efficiency. Or, if greater economies and improved product performance can be achieved with a special-purpose fastener, he will design a Shakeproof product specifically for your application. In either case, the Shakeproof idea engineer will provide you with samples to use and test in your own plant.

Arrange for a Shakeproof idea engineer to visit your plant soon. Discover how Shakeproof On-the-Line Engineering can help cut *your* fastening cost . . . where it matters most!

SEND FOR THIS FREE BOOKLET "On-the-Line Engineering" gives specific examples of time and money saving Shakeproof fastener applications and offers free samples.

**Studies have shown that the cost of applying a fastener is more than four times the cost of the fastener itself.*

Look to Shakeproof—the Leader in Fastening.

SHAKEPROOF
"FASTENING HEADQUARTERS"®
DIVISION OF ILLINOIS TOOL WORKS
St. Charles Road, Elgin, Illinois
In Canada: Shakeproof/Fastex
Division of Canada Illinois Tools Limited, 67 Scarsdale Road, Don Mills, Ontario

Circle 432 on Page 19

NEW ONE-OF-A-KIND MICROGRAPH

draws pictures for bearing research

This greatly magnified stylus is drawing a picture of the microscopic imperfections in a bearing raceway . . . measuring each one to within a few millionths of an inch. The picture-on-tape which comes out of this specially modified micrological instrument is an important tool in BCA's research on ball bearing performance.

This is just one of the precision instruments in the Temperature-Humidity-Controlled Instrumentation Room which is the center of BCA research on bearings. The result of this program is revealed in on-the-job performance of BCA bearings. They roll dependably under heavy loads and all kinds of adverse conditions.

New testing facilities at the BCA laboratories also include specially designed equipment, often identical with equipment in customers' plants. Here, BCA bearings are tested to exceed customer specifications *under the exact operating conditions experienced by the customer!*

BCA ball bearings are standard original equipment . . . replacement, too . . . for nearly every kind of industry. For example, automotive, earth moving, agricultural and machine tools. The wide line of ball bearing sizes and types, plus BCA's research and extensive new testing facilities, pavs off for bearing users. Consider the performance record of BCA ball bearings the next time you purchase or specify bearings. For more information, or for assistance with bearings problems, contact Bearings Company of America, Division of Federal-Mogul-Bower Bearings, Inc., Lancaster, Pa.

BCA

BEARINGS COMPANY OF AMERICA

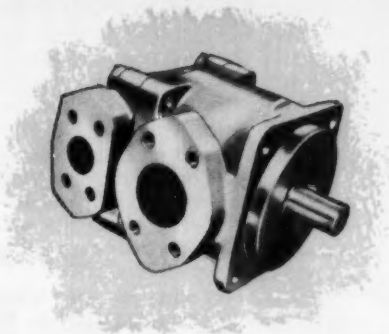
ball bearings

DIVISION OF
FEDERAL-MOGUL-BOWER
BEARINGS, INC.

Circle 433 on Page 19

VANE PUMP POWER for CASE®

2000 PSI...BY DENISON



2000 PSI HYDRAULIC PUMP
. . . is incorporated into power systems of dozens of types of earthmoving equipment by leading manufacturers. Denison 2000 psi hydraulic power gets jobs done faster with dependable trouble-free operation for toughest workloads.

DESIGNERS ENGINEERS . . .
Write for your copy of Bulletin P-9-3 on Denison "T1D" Series Vane Pumps. Includes complete specifications and operating data.

These completely new Case tractor shovels—the W-10 and W-12 TERRALOAD'R®—deliver outstanding work capacity. They're products of the J. I. Case Co., Racine.

Ar[illegible]ra-efficient Denison hydraulic power is helping these high-speed Case units do [illegible]avating, loading, grading, hauling and materials-handling jobs faster . . . at *lower operating cost.*

The W-10 (2 cu. yd.) and W-12 (2½ cu. yd.) TERRALOAD'R® dump-buckets get high efficiency, low-cost power from a single Denison 2000 psi vane pump.

Key advantage – high volumetric efficiency is *continuous* in Denison pumps . . . no drop-off in work speed – no sluggish operation to slow up the job.

Plus these advantages –"cartridge" construction of Denison pumps means speedy in-field servicing. All-weather starting features prevents pump damage. Denison pumps guarantee less weight, less cost-per-horsepower . . . more payload per dollar in your earthmoving equipment.

Your Denison Hydraulic Specialist can tell you more about significantly improving equipment performance with *hydraulic power to 5000 psi.* Call him in to discuss *making your equipment more profitable to the man who buys it!*

DENISON ENGINEERING DIVISION
American Brake Shoe Co.
1240 Dublin Road • Columbus 16, Ohio

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DENISON HydrOILics

HYDRAULIC PRESSES • PUMPS • MOTORS • CONTROLS

RB&W FASTENER BRIEFS

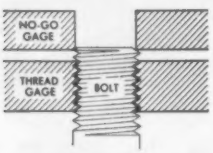
RUSSELL, BURDSALL & WARD BOLT AND NUT COMPANY

Technical-ities

By Fred E. Graves

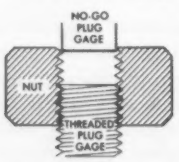
Proper inspection for screw threads

Thread inspection should answer two questions. (1) Will the threads allow easy *assembly?* (2) Is there sufficient thread depth for strength?



EXTERNAL THREADS

Strength requires sufficient thread flank engagement, which is checked by a *minimum* major diameter *plain* ring "no go" gage. Assembly is controlled by thread lead and maximum metal, which are checked by a *threaded* ring "go" gage.

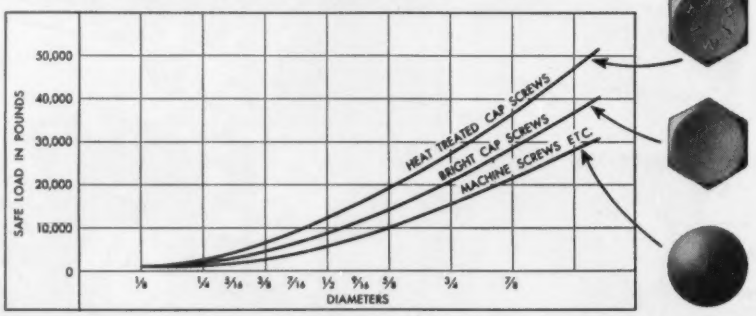


INTERNAL THREADS

The same reasoning holds true here. Use a threaded plug "go" gage to determine any interferences from thread lead or thread diameter that hinder ease of assembly. The unthreaded "no go" plug will assure proper thread depth for sufficient flank engagement.

Checking both thread lead and pitch diameter with two threaded "go" and "no go" gages not only increases inspection cost but also permits acceptance of pieces with insufficient thread metal.

How to simplify selection of fastener material



Safe loads for fasteners made from the three most common steel grades are shown on these curves. Curve for Grade 2 is smooth through the ⅞" size. There is no drop in proof load because RB&W fasteners up to 6" long are cold headed even in 1" diameters.

Basic job of a mechanical fastener is *physical.* It's designed to exert a clamping force.

Fasteners from a *standard* analysis of steel satisfy a majority of the usual requirements for this function. Most times, then, specifications should concern themselves solely with *physicals* for the job. Asking for certain chemical analyses to get the right physicals is doing it the hard way. It can create a needless cost penalty besides.

WIDE RANGE OF LOADS

Generally, the desired physicals can be delivered by a combination of cold working and heat treatment of one of the following common grades.

Grade 1 (or SAE 1010) steel goes into fasteners that offer a design load of 30,000 psi, such as carriage bolts and machine screws.

Grade 2 (or SAE 1018, 1020, 1021) steel goes into bright hex screws and similar items with a recommended design load of 40,000 psi in sizes up to ¾". SAE proof load then drops from 17,350 lbs. in ¾" size to 12,900 lbs. in ⅞" size *unless cold heading is specified!* This is because larger fasteners are often hot headed, resulting in some annealing. The strengthening effect of cold working is lost.

Grade 5 (SAE 1038) steel provides high strength heat treated bolts and hex screws with 60,000 to 80,000 psi design load range.

USE THE FULL INHERENT STRENGTH

When calculated load on a fastener is below those values, you're wasting its strength and cost. Using the smallest size fastener consistent with the load, and tightening to its maximum load actually increases joint strength.

When you need an alloy steel because of space or weight or higher temperature or strength requirements, specifying physicals will automatically force your supplier to go to high alloy steel.

You will get what you need without selecting the exact alloy to be used. Just be sure you're served by a technically qualified and experienced fastener manufacturer.

Bulletin DC-2 gives other helpful hints. Send for it—or the RB&W Man. Russell, Burdsall, & Ward Bolt and Nut Company, Port Chester, New York.

Plants at: Port Chester, N.Y.; Coraopolis, Pa.; Rock Falls, Ill.; Los Angeles, Calif. Additional sales offices at: Ardmore (Phila.), Pa.; Pittsburgh; Detroit; Chicago; Dallas; San Francisco.

Circle 435 on Page 19

Circle 436 on Page 19→

do you know these facts about this fabulous plastic?

Do you know that:

- National Vulcanized Fibre is not a paper, or a fiber-board, but a tough cellulosic plastic . . . the oldest plastic of all!
- Despite a parade of new exciting plastics (and we make many of them), Vulcanized Fibre goes on sparking thousands and thousands of bright, new, cost-cutting ideas that other plastics aren't equal to!
- Vulcanized Fibre offers a most unusual combination of electrical and mechanical properties, giving your imagination more leeway, and *you* a greater chance of fingering the exact properties you want!
- National Vulcanized Fibre has outstanding arc resistance, low thermal conductivity, amazing resiliency and shock-absorbency, high abrasive resistance. It is fungus resistant. It soaks up noise!
- National Fibre can be formed or deep-drawn into intricate shapes; and machined, polished, painted, lacquered, embossed . . . even used in combination with other materials, such as aluminum, wood, rubber, copper.
- When used for railroad track insulations, Vulcanized Fibre can take the constant pounding of trains, yet can gently *cushion* fragile electronic parts, when used for containers. And it has stood up under 22,000° F for ten seconds without serious loss in weight!
- Vulcanized Fibre weighs half as much as aluminum, one-third as much as steel, is smooth as glass, and is one of the *strongest* materials known per unit of weight!
- There are sixteen standard grades, including a fire-resistant "Pyronil." And the cost of National Vulcanized Fibre is in the cents bracket, compared to dollars for many other types of plastics.
- *This* could be the plastic you are looking for now!

For help on a present problem, or for information on National Vulcanized Fibre and samples, just write Dept. R , or contact your nearby NVF Sales Office. You'll find the 'phone number in Sweet's Product Design File 2b/Na.

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VULCANIZED FIBRE CO.
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Wanted: Engineers

with an interest in writing

Like to break into an interesting field where you'll make good use of your engineering talents — yet have a chance to develop new skills?

We're looking for several men with engineering experience and a yearning to write or edit. As an editor on MACHINE DESIGN, you would broaden your engineering background in a job that provides stimulating contact with people in many engineering areas.

You don't have to have actual writing or editing job experience, although we expect definite ability in handling the English language. An ME or EE degree plus several years of design-engineering experience would be ideal, but we'll be happy to consider equivalent qualifications. Age: 25 to 35.

If you've worked in a design-engineering specialty area, we'd like to hear about it. We're interested in any job experience or training in:

- Mechanical drives, controls, systems
- Mechanical components, assemblies
- Electrical or electronic drives, controls, systems
- Hydraulic or pneumatic systems, drives, controls
- Materials and finishes selection or specification
- Design for manufacture or production design

Our headquarters are in Cleveland. There is opportunity for travel to engineering meetings, expositions, and manufacturing companies. Salary will depend on your background and experience.

If you are interested, send a resume of your engineering background, and any evidence you may have of writing ability (we'll return this if you wish) to: Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

MACHINE DESIGN

Circle 438 on Page 19→

Quiet...

WAGNER Polyphase Resilient Mounted Motors in ratings through 10 horsepower

Quiet, vibration-free performance is essential when motors are installed in areas where noise must be held to a minimum . . . in hospitals, churches, schools, office buildings, restaurants and similar locations where quiet is needed or wanted.

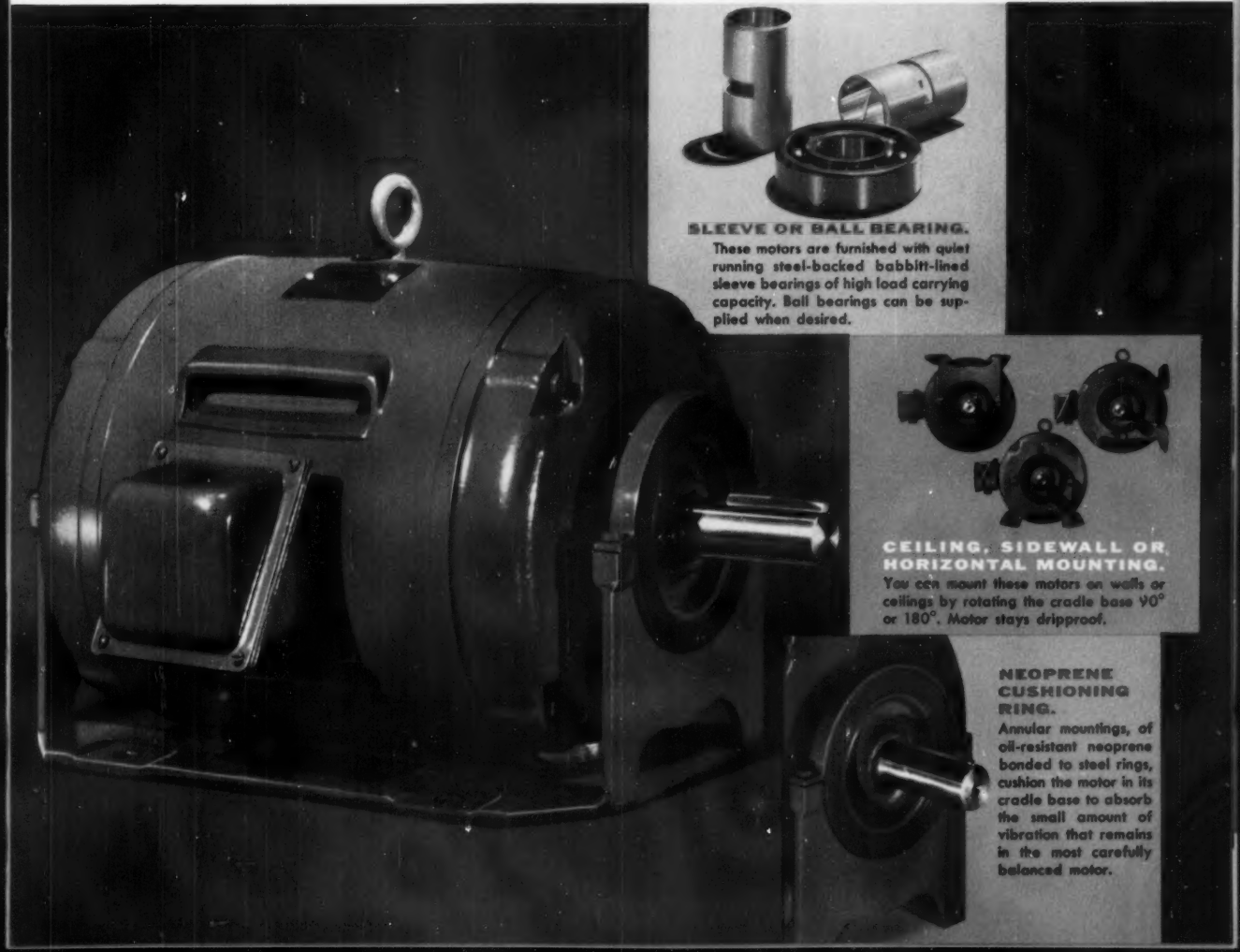
Such installations have created a need for larger polyphase motors that whisper while they work. Wagner has met this need by expanding its line of polyphase resilient mounted motors to include standard ratings through 10 hp.

You certainly have applications that call for a smooth running motor, cushioned by resilient mountings. To make sure they're quiet, specify Wagner Polyphase Resilient Mounted Motors. Only Wagner can provide an entire range of ratings through 10 hp.

Constant research and development have kept Wagner up front in electric motor design for more than 65 years . . . made the name Wagner one you can depend on in choosing electric motor drives.

Your nearby Wagner Sales Engineer can help you select the right motor to meet your requirements. There are Wagner branch offices in 32 principal cities.

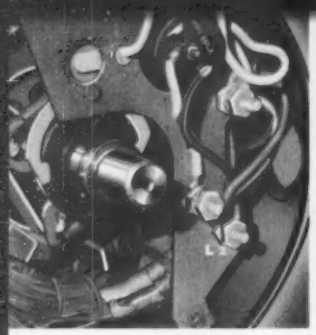
Wagner Electric Corporation
6400 PLYMOUTH AVENUE, ST. LOUIS 33, MISSOURI



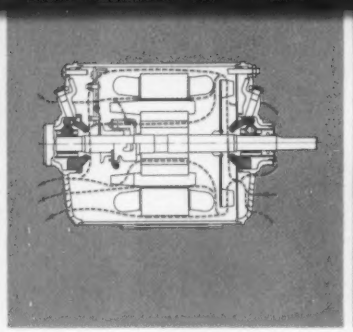
SLEEVE OR BALL BEARING.
These motors are furnished with quiet running steel-backed babbitt-lined sleeve bearings of high load carrying capacity. Ball bearings can be supplied when desired.

CEILING, SIDEWALL OR HORIZONTAL MOUNTING.
You can mount these motors on walls or ceilings by rotating the cradle base 90° or 180°. Motor stays dripproof.

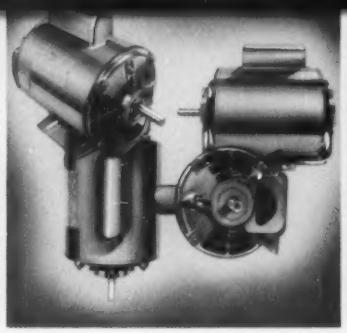
NEOPRENE CUSHIONING RING.
Annular mountings, of oil-resistant neoprene bonded to steel rings, cushion the motor in its cradle base to absorb the small amount of vibration that remains in the most carefully balanced motor.



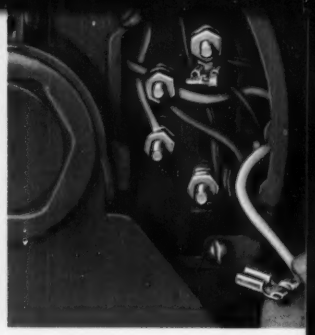
Quick Break Switch. The starting winding is disconnected from the line by this Wagner designed switch . . . test proved to make more than a million breaks. (That adds up to two starts per hour for 50 years!)



Efficient Cooling System. The improved ventilating system used in these motors directs a large volume of air through the motor to effectively reduce temperatures and add to motor life. Cross section indicates direction of air flow.



All-Angle Operation. The sleeve bearing design, in fractional hp ratings, has a positive lubrication system that permits operation in any position . . . can mean important savings in motor costs to manufacturers.



Quick Connect Terminals. Brass tabs on terminal studs permit quick, easy connection of leads . . . cut wiring time to speed assembly line production. Simply press the lead receptacle on to the stud—a positive connection is assured.

NO STARTING PROBLEMS with WAGNER CAPACITOR-START MOTORS

Pack more power into less space...give long troublefree service...are easy to hook up

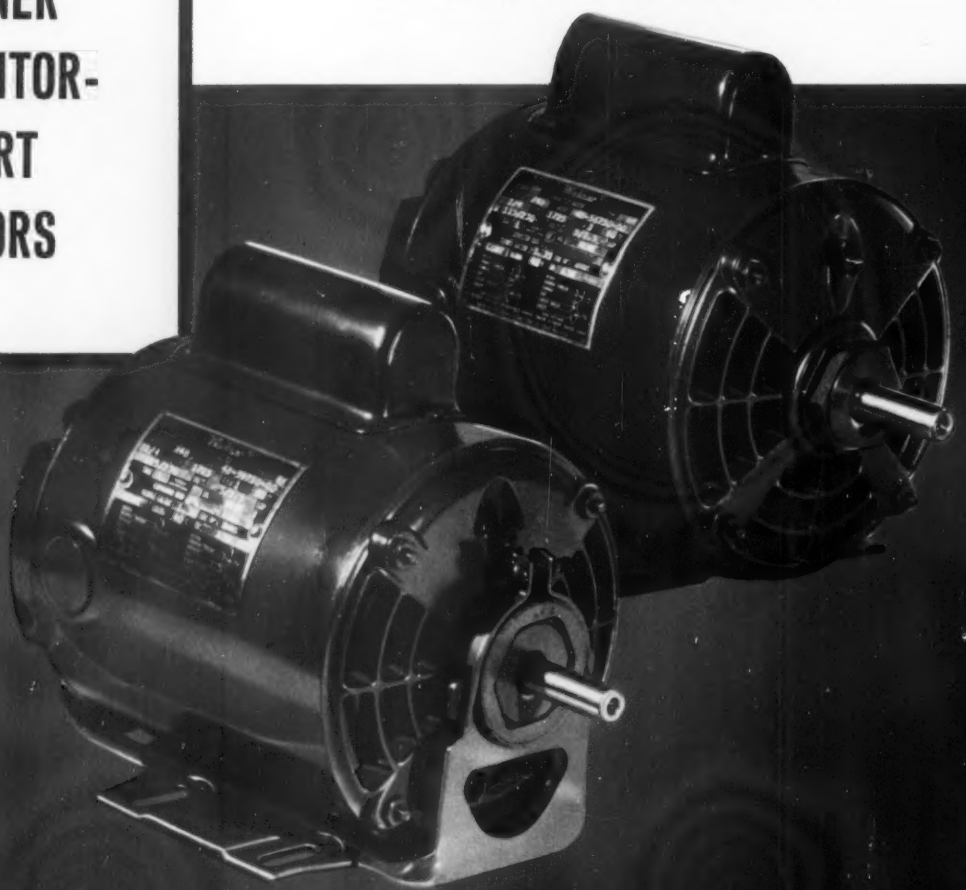
Here are general purpose single-phase motors that have high starting torque and high pull-in torque. When used in the proper application and supplied with voltage close to their rating, they'll give positive starts every time. Troublefree operation is assured . . . thanks to the positive action of the Wagner governor mechanism and long life quick-break switch.

Wagner Type RK Motors pack more power into less space. Small enough to fit in tight spots, their ruggedness is built-in . . . permits direct mounting. And, sleeve bearing fhp models can be operated in any position. They are available in a range from 1/6 through 5 horsepower, with sleeve or ball bearings, and with rigid bases or resilient mountings.

Get these motors from leading motor distributors in your city, or from Wagner sales offices in 32 cities across the country. Your Wagner Sales Engineer will be glad to help you select the right motor for your application. Wagner Bulletin MU-217 gives full details on Capacitor-Start Motors.

Wagner Electric Corporation
6400 PLYMOUTH AVENUE, ST. LOUIS 33, MISSOURI

WM60-12



NOW... *Twin-Size*

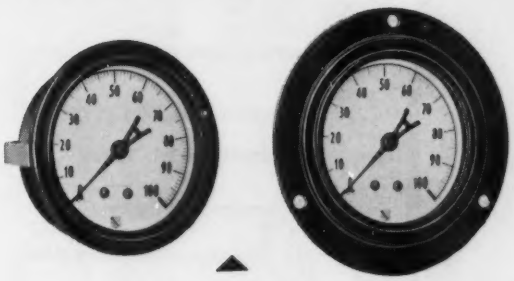
Pressure Gauges and Thermometers for "companion" installation

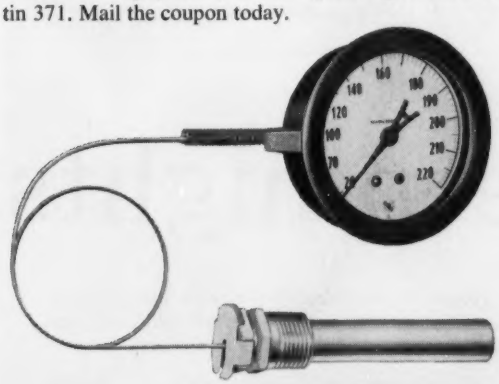
Appearance rates with high accuracy when gauges and thermometers are essential to the equipment you have "on the boards."

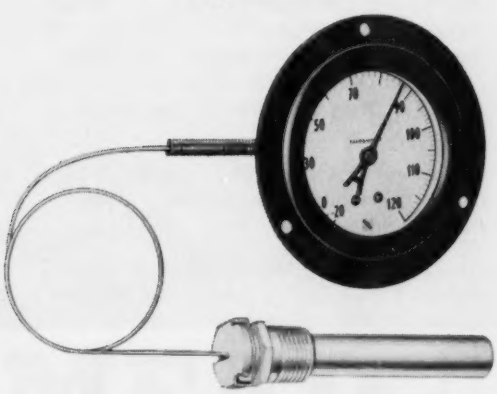
These size-matched pressure and temperature indicators are also similar in case, dial, and pointer design. Such "look alike" characteristics add a quality look to the design of any panel or other mounting surface.

Ashcroft Gauges and American Thermometers have a reputation for sustained accuracy and ruggedness in the most demanding power and processing industry services. Their fine quality is matched by long-term economy on all recommended applications.

Get complete technical data on these 2½" Ashcroft Gauges and American Thermometers, then select those best-suited to the equipment you are engineering. Write for Bulletin 371. Mail the coupon today.







2½" ASHCROFT GAUGES

"U" Clamp and Front Flange Styles
Steel Case: ⅛" and ¼" NPT centered back connection.

Ranges. Pressure: 0-15 psi to 0-600 psi. Vacuum: 0 to 30" mercury, or 0 to 34 ft. of water. Compound: 15 psi and 30" to 300 psi and 30".

Recommended Applications: For equipment such as portable compressors, pumps, water tanks, industrial washers, and pressure lines.

2½" AMERICAN THERMOMETERS

"U" Clamp and Front Flange Styles
Vapor pressure actuation. Steel case. Plain bulb; or cadmium-plated steel well for corrosion protection.

Ranges. Fahrenheit: Ranges from minus 40°/65° to 260°/450°. Centigrade: Ranges from 0°/100° to 90°/185°.

Recommended Applications: For air conditioning units, oil circulating systems, farm milk tanks, commercial frozen food cabinets, walk-in coolers, refrigeration lines.

WRITE FOR BULLETIN 371

Manning, Maxwell & Moore, Inc.
East Main Street, Stratford, Connecticut

Send me complete technical information on

☐ 2½" Ashcroft Gauges
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Stratford, Connecticut

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←Circle 438 on Page 19

Circle 439 on Page 19

FOR THE ENGINEER

who can't sleep nights

If you're losing sleep over a sticky problem in automatic control, AE can help—because AE has a reputation for making things *work* automatically.

It's not surprising, considering our unique experience in the design of circuits and components for automatic telephone exchanges.

What's more, AE relays and stepping switches are unique in their own right—because they're built to have substantially zero variation in operating characteristics *for life.*

As an example: the AE Class B Relay, illustrated, provides hundreds of millions of operations with unfailing contact reliability, and seldom needs maintenance. For this reason, it is probably the most inexpensive relay you can use where infallibility is an essential.

AE relays and stepping switches are custom-made to *your* specifications—and are also available wired and assembled into complete control units. And we're always glad to suggest specialized circuits that may cut your end costs.

Want more information? Just write the Director, Control Equipment Sales, Automatic Electric, Northlake, Illinois.

Also yours for the asking: Circular 1702-E, *Relays for Industry,* and a new 32-page booklet on *Basic Circuits.*

AUTOMATIC ELECTRIC

Subsidiary of
GENERAL TELEPHONE & ELECTRONICS

New! FREE CUSHIONS*

MEAD
DURA-LIFE
CYLINDERS

Compare these prices!

1½" Bore — $29.95 **3¼" Bore — $46.40**
2½" Bore — $37.80 **4" Bore — $53.35**

Prices slightly higher West of Rockies.

Write for complete Mead Air Power Catalog

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Circle 441 on Page 19

in only 90 days...

101 aluminum fabricators have ...Amchem's newest

ALODINE 1200S protects aluminum best ...at less cost, in less time!

To the hundreds of long-time users of Amchem Alodine—the first, low cost effective surface conversion treatment for aluminum—add a new host of fabricators who are employing the newest Alodine development—ALODINE 1200S!

If you are producing aluminum—any type of aluminum—you'll want to investigate the production advantages and profit potentialities of this new Alodine pre-paint process that provides constant, uniform quality as well as big savings in time, equipment and processing costs!

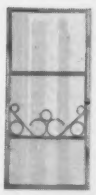
Through increased chemical activity ALODINE 1200S slashes processing time *up to 50 percent!* A 1200S system can be installed on your production line quickly and conveniently . . . and bath is maintained chemically . . . no special equipment required to control contamination! In an ALODINE 1200S system, products can be processed through continuous dip in the same time cycle other conversion coatings require for continuous spray lines! That means lower initial equipment and maintenance costs, wider range of product applications regardless of the application method—brush, dip, continuous strip or spray. ALODINE 1200S is qualified under Government Specification MIL-C-5541.

ALODINE 1200S is Amchem's positive answer to constant uniform quality in aluminum processing. Put its assured protection and production flexibility to work for your aluminum products and market them with greater confidence!

switched to Alodine 1200S conversion coating!

FASTER, LOW COST, EFFECTIVE AND FLEXIBLE, ALODINE 1200S IS PROVIDING NEW HIGHS


aluminum stop signs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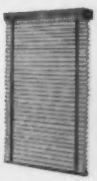
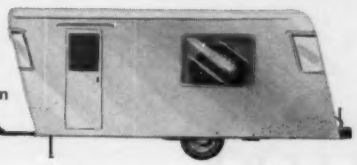
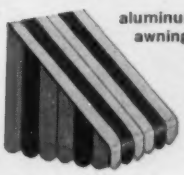

aluminum venetian blinds

IN CORROSION RESISTANCE AND PAINT BONDING QUALITIES TO THESE AND


aluminum cameras


aluminum house trailers


aluminum awnings

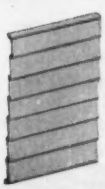
MANY MORE FINE PRODUCTS IN THE ALUMINUM INDUSTRY. YOU, TOO, CAN

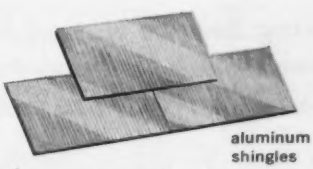

aluminum boats

aluminum license plates


aluminum missile parts

UPGRADE YOUR PRODUCTS' CONSUMER APPEAL WITH ALODINE PROTECTION.


aluminum siding


aluminum shingles

aluminum mail boxes

CONTACT YOUR NEAREST AMCHEM REPRESENTATIVE FOR COMPLETE DETAILS!

AMCHEM

ALODINE 1200S

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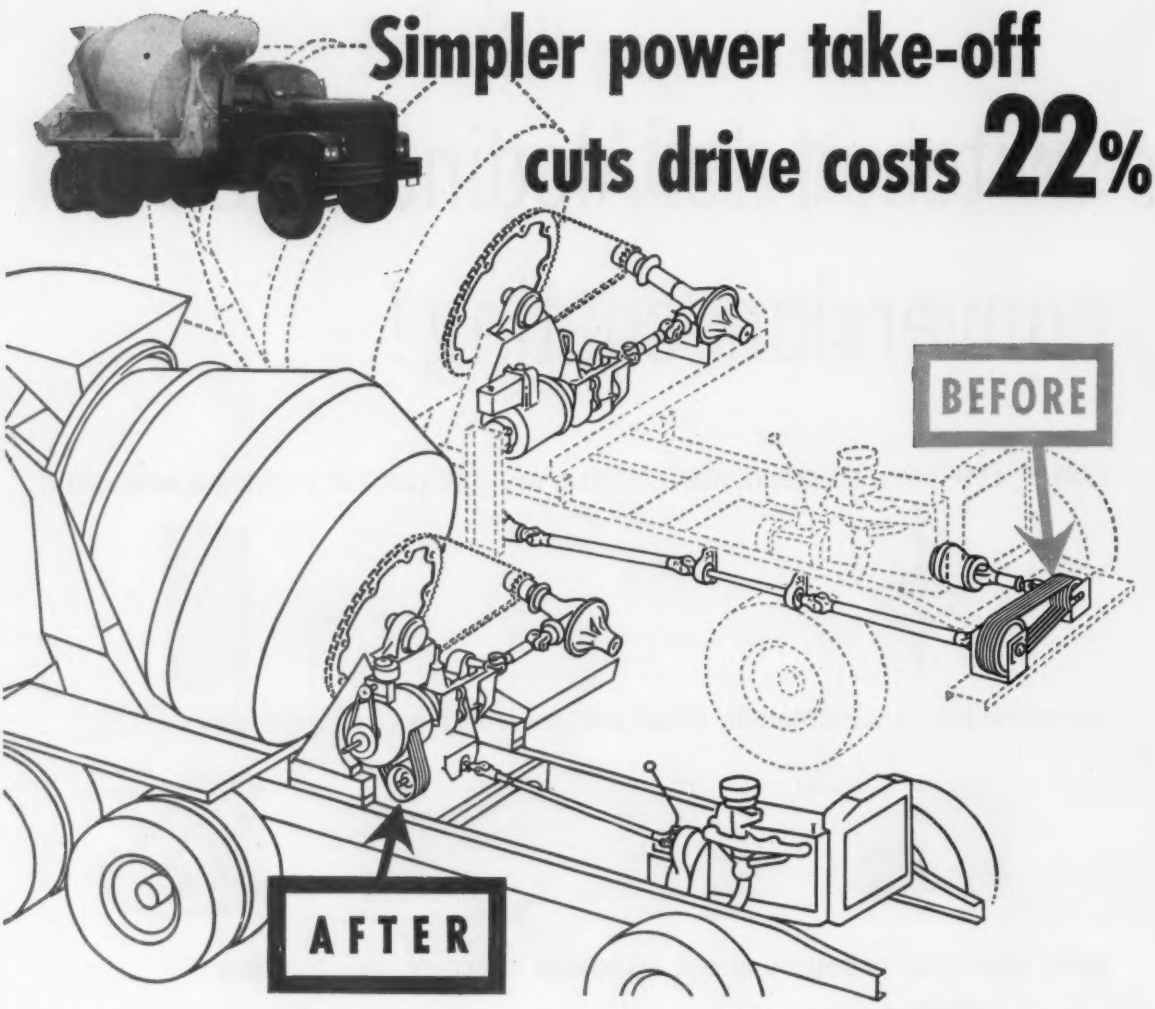
(Formerly American Chemical Paint Co.)

AMBLER, PA. • Detroit, Mich. • St. Joseph, Mo. • Niles, Calif. • Windsor, Ont.

Circle 442 on Page 19

Simpler power take-off cuts drive costs 22%



Super HC V-Belts—packing higher hp capacity in smaller space than conventional V-belts—have eliminated need for front-end power take-off on concrete-mixer trucks made by Concrete Transport Mixer Company of St. Louis, Mo.

By letting take-off be shifted to rear, Super HC V-Belts cut drive costs alone by 22%, besides saving weight and cost of complex linkage and other components of the former front-end drive.

With Super HC, sheave diameters can be cut 30% to 50%, drive space up to 50%, and drive weight 20% and more. A product of Specialized Research in the world's largest V-belt laboratories, Super HC V-Belts are helping many manufacturers put more compact, lighter weight, lower cost drives on all types of machines.

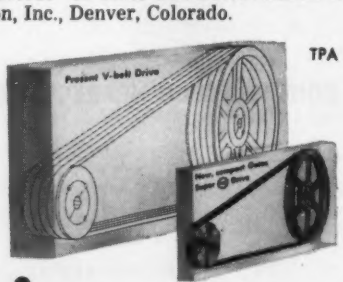
Engineering Service Nation-Wide

What's *your* power transmission design problem? Your Gates Field Representative is ready to help you solve it—to cut space, weight, cost with Super HC V-Belt Drives. Ask him for your free copy of *"The Modern Way to Design Multiple V-Belt Drives"* or write The Gates Rubber Company Sales Division, Inc., Denver, Colorado.

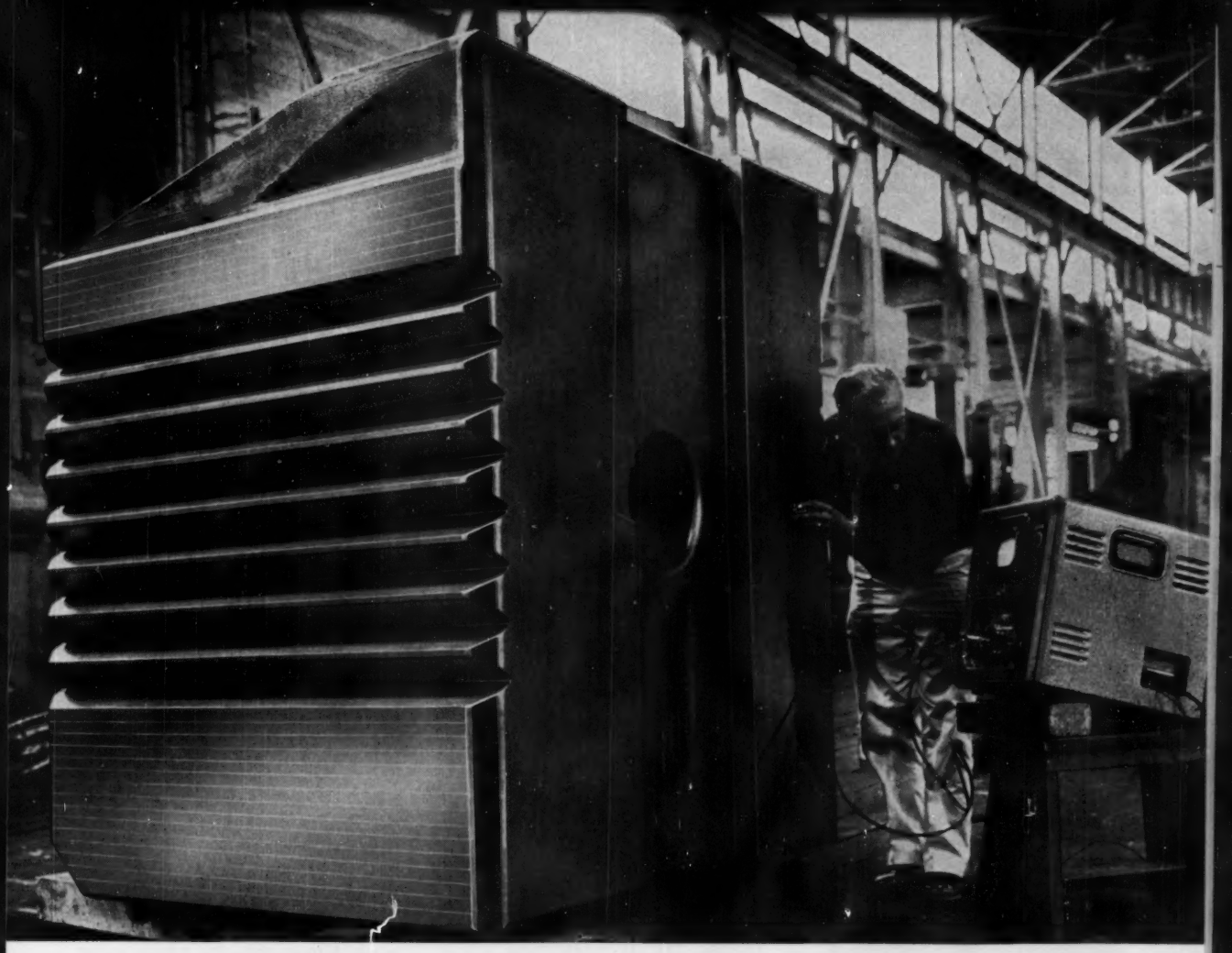
TPA 485

The Gates Rubber Company, Denver, Colorado
Gates Rubber of Canada Ltd., Brantford, Ontario

Gates *World's Largest Maker of V-Belts*



Gates Super HC V-Belt Drives same hp capacity in smaller "package"



We think it's the largest forged hammer ram ever made

It weighs in at 50,000 pounds. And it measures 54¼ inches from top to bottom—59⅜ inches from side to side—66 inches from front to back. Here at Bethlehem, we've never heard of a larger *forged* hammer ram. Have you? If so, we'd certainly like to know the details. Would you be good enough to drop a line or two to Forgings Sales? (And end our suspense over whether we've chalked up another record, or an also-ran?)

A few other facts about this hammer ram: we forged it from nickel-chrome-molybdenum-vanadium steel; we heat-treated and tested it to our customer's specifications; and, as you can see, we furnished it finish-machined, ready to start pounding in a steam drop hammer.

Although this ram is surely a giant in its class, it's a pygmy compared to some of the forgings we've made. Our shops turn out the largest forgings ever needed—some weighing over 200 tons. (Some of the smallest, too—drop forgings, for example, that weigh as little as one pound.)

Call us when we can be of service to you or members of your staff. Our engineers will gladly cooperate, from the planning stage to the finished product—whatever the type, size, or design of forging you require.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

Export Distributor: Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

Circle 444 on Page 19

Design Data on Resilient Clutch Facings

8

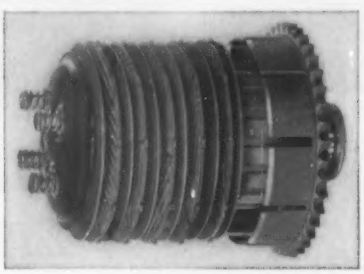
SOME CLUTCH PROBLEMS SOLVED BY RESILIENT FACINGS

Eliminating Clutch Burn-Out

The clutch in a Triumph motorcycle gets a workout in road races. It has to engage quickly at speed differentials as high as 4000 rpm at full throttle as many as 20 times a minute. The clutch plates are splash lubricated with oil at an ambient temperature of 250° F. Under these severe conditions, clutch burn-out was a constant problem.

After testing many materials, engineers selected Armstrong NC-733, a cork-and-rubber facing. They found that NC-733 engaged quickly, reducing the slippage that builds up heat and destroys facings.

Triumph has eliminated clutch burn-out and gained a competitive speed advantage by adopting NC-733 for all heavy-duty clutches.

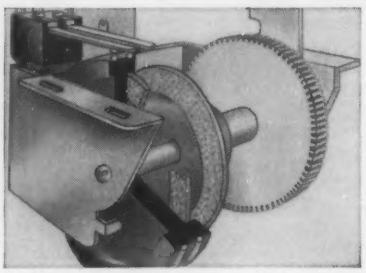


Triumph Motorcycle Clutch

Improving Instrument Accuracy

Leeds and Northrup potentiometer-type industrial recording and control instruments depend for their accuracy upon standardizing mechanism in which a rheostat compensates for declining battery voltage. The rheostat has a friction facing which is engaged by a friction-faced drive gear.

Since random motion would ruin accuracy, the facing must engage instantly and positively under only 28 ounces of closing force and then break away cleanly. The facing also must slip for a short time when the rheostat reaches the end of its travel.



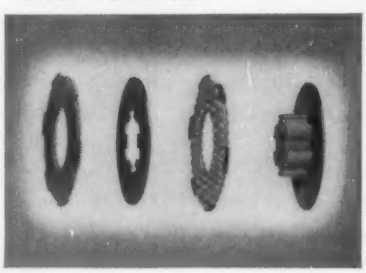
L. & N. Recording Potentiometer Clutch

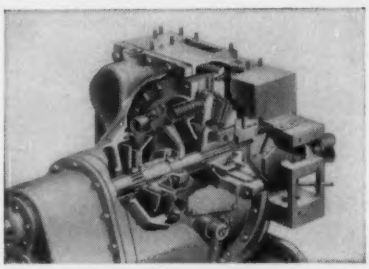
An Armstrong facing keeps the Leeds and Northrup recorder more than 99½% accurate. And there is no wear from slippage, so neither facing ever has to be replaced.

Simplifying Clutch Design

Three Armstrong facings deliver the same torque capacity as the eight metal plates previously used in this automatic washer clutch, cutting fabrication and assembly costs significantly. The switch to resilient facings solved both a production and a maintenance problem. The old clutch with metal plates required a half-hour break-in period plus an oil drain and refill operation. In spite of this precaution, metal particles continued to damage gears and facings, causing failure in service. Now, the use of resilient facings has cut out the break-in run and, more important, the facings last the life of the appliance.

Automatic Washer Clutch





Caterpillar Motor Grader Clutch

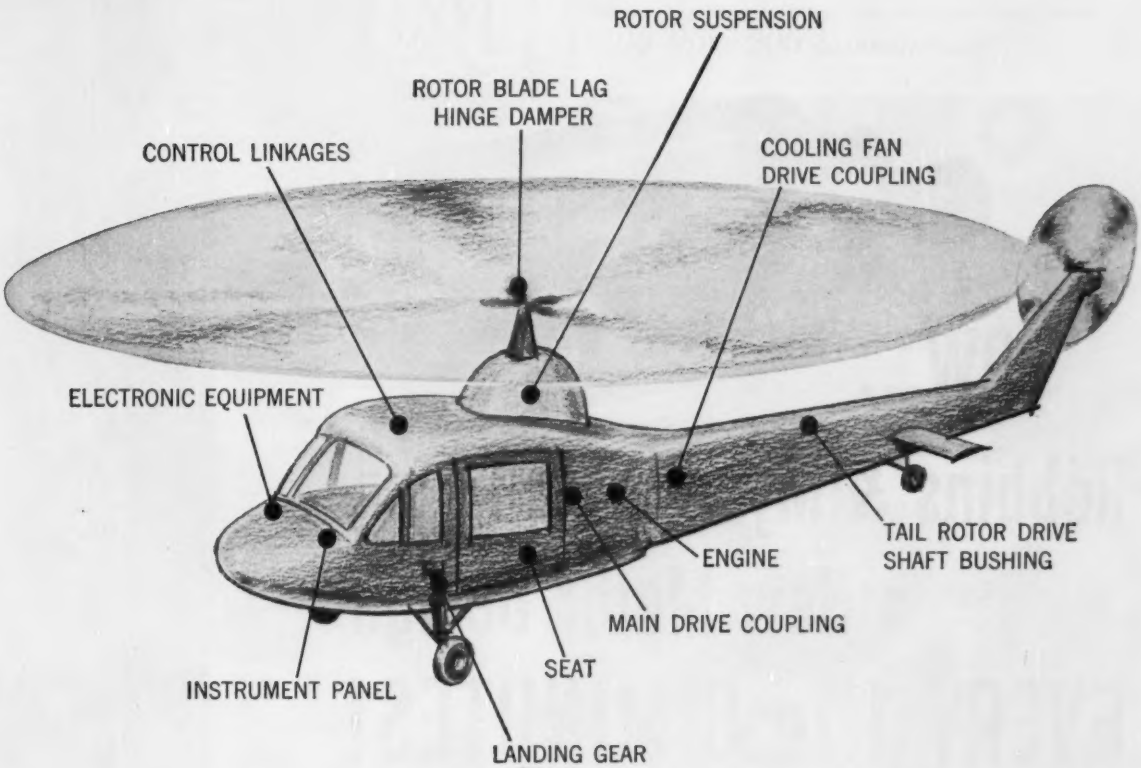
Increasing Clutch Life

In heavy construction work, this motor grader clutch has to engage as often as 20 times a minute, transmitting 375 ft-lbs of torque. The facings of the dry clutch wore down rapidly, making frequent adjustments and replacements necessary. Caterpillar engineers converted to an oil-filled clutch using an Armstrong resilient facing. This Armstrong friction material provides as much torque capacity when coated with oil as the original clutch facing did dry — eliminating the need for more plates, bigger plates, or higher engagement pressure. The new clutch with Armstrong resilient facings lasts five to ten times longer and requires no adjustments for facing wear.

Clutch designers are using resilient facings more widely today than ever before. Recent advances in compounding have opened up new applications that were once restricted to more costly, less efficient materials. If you'd like complete information on how to use these versatile materials, write for your free copy of "Resilient Friction Materials." This new 44-page manual contains charts, graphs, and performance data plus a check sheet to help you select the right friction material for your application. Address your request to Armstrong Cork Company, Industrial Division, 7203 Dean Street, Lancaster, Pennsylvania.

Armstrong RESILIENT FRICTION MATERIALS

1860-1960 Beginning our second century of progress



critical points for *vibration/shock/noise* control

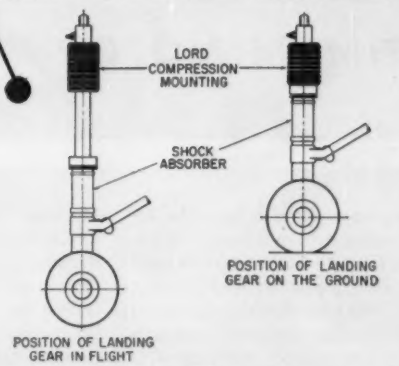
Improved flight characteristics, less noise and increased service life are major design objectives of helicopter engineers. LORD offers maximum assistance through advanced vibration/shock/noise control techniques and superior materials.

At critical points, LORD elastomeric mountings combat the undesirable effects of engine vibration, rotor disturbances, unbalance, taxiing shocks, operational noise, shaft misalignment and blade bottoming.

Close teamwork between helicopter engineers and LORD results in vital "breakthroughs" in cost, size, weight or service life. For example, an elastomeric rotor blade lag hinge damper provides improved performance with substantial savings in cost and weight.

Utilize LORD capabilities in vibration/shock/noise control to implement your helicopter, VTOL, STOL or convertiplane project. LORD experience plus modern facilities for research, custom engineering, production, and testing will assure an optimum solution. Contact your nearest Lord Field Engineering Office or the Home Office, Erie, Pa.

ADVANCED MATERIALS PERMIT UNIQUE DESIGNS



The low temperature flexibility, oil resistance and excellent damping properties of Lord BTR® elastomer are utilized in new landing gear spring. BTR compression mounting absorbs peak energy on landings, then protects landing gear and fuselage during ground operations.

FIELD ENGINEERING OFFICES

ATLANTA, GEORGIA - CEdar 7-9247
BOSTON, MASS. - HAncock 6-9135
CHICAGO, ILL. - MIchigan 2-6010
DALLAS, TEXAS - Riverside 1-3392
DAYTON, OHIO - BAldwin 4-0351
DETROIT, MICH. - Diamond 1-4340
KANSAS CITY, MO. - WEstport 1-0138
LOS ANGELES, CAL. - HOllywood 4-7593
NEW YORK, N. Y. - Circle 7-3326
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SAN FRANCISCO, CAL. - EXbrook 7-6280
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"In Canada—Railway & Power Engineering Corporation Limited"

LORD MANUFACTURING COMPANY • ERIE, PA.

LORD®

NOW... Robbins & Myers Calculates a New Motor Design EVERY 1 to 6 MINUTES!

R&M Engineers Explore Hundreds of Design Combinations to Achieve OPTIMUM MOTOR PERFORMANCE!

How many ways *could* a motor be designed — a polyphase motor, for example? At least 27 basic variables offer 27^{27} (30 zeros) possibilities! Theory, of course, but still there's a colossal number even after obviously impractical designs are ignored. Working with slide rule, an engineer can calculate maybe four designs per day . . . and that's the time-consuming way it was done once. But now ROBBINS & MYERS engineers can explore hundreds of design possibilities, using their Data Processing System. With infallible accuracy, IBM's 20,000 digit "Magnetic Memory" is able to calculate a new motor design every one to six minutes! Because R&M engineers can now explore hundreds of design combinations before they make a final decision, you get the one motor that will deliver optimum on-the-job performance! And at no extra cost!

"Mechanized" mathematics at ROBBINS & MYERS also gives engineers more time for design *vision* and *decision*, which no machine can possibly provide . . . and enables them to improve existing motors by probing alternate design possibilities.

If you are ordering integral or fractional HP motors, or series motor parts, remember this fact: *the greater the number of practical design possibilities the manufacturer explores before the motor is produced, the better the motor will perform!* When your motor comes off the assembly line at ROBBINS & MYERS, you can be certain you are getting the best design possible, perfectly adapted to your requirements, and quality-built to perform dependably for years to come!

ROBBINS & MYERS, INC.

motors, household fans, Propellair industrial fans, hoists, Moyno industrial pumps

SPRINGFIELD, OHIO • BRANTFORD, ONTARIO

Circle 448 on Page 19

MOTORS

1/200 thru 200 horsepower

Design answers in seconds from IBM 20,000 digit magnetic memory!

Integral Motors (left), range from 1 to 200 HP in single-phase, direct current, polyphase, totally-enclosed fan-cooled, and explosion-proof types.

Standard Fractional HP Motors (right), are available in polyphase induction, capacitor start, resistance split-phase, and permanent split capacitor, in open and totally-enclosed types.

Precision-Made Universal Motors and Series Motor Parts (left), enable manufacturers of electric power-driven equipment to make the motor an integral part of their product.

Business Machine and Commercial Appliance Motors (right), are available in standard or custom designs.

IF A *MINIATURE* OR *INSTRUMENT* BEARING IS NEEDED . . .

NEW HAMPSHIRE

. . . IS THE *SOURCE!*

To meet the exacting requirements of your applications, New Hampshire maintains a full line of miniature and instrument bearings for research and development, prototypes and replacements at all regional offices. (Production quantities are shipped direct from our main plant.) NHBB sales engineers are always on call to discuss your particular needs and make specific recommendations.

Retainer Bearing Plain

Retainer Bearing Flanged

Retainer Bearing Shielded

Retainer Bearing Flanged & Shielded

RETAINER BEARINGS

This is one of the most frequently specified types for instrument applications. Available with newly designed crown retainers. This design permits even ball spacing, low torque, and most consistent performance. *Over 150 standard types and sizes are listed in our Design Manual.*

SIZES

(Available in a wide selection of combinations within the following ranges)

	BORE	O.D.	WIDTH
Min.	.0469	.1562	.0625
Max.	.3125	.6250	.1960

EXTENDED INNER RINGS . . . available on all above types

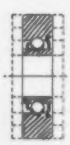
FULL BEARINGS

Full bearing (Available plain or flanged)

Specified for applications requiring maximum radial load capacity. Not suited to low torque requirements. *Over 21 standard types and sizes.*

SIZES	BORE	O.D.	WIDTH
Min.	.0250	.1000	.0312
Max.	.3125	.5000	.1562

UP and WAFER BEARINGS



A wafer bearing compared with standard equivalent

Expressly designed for use in synchros, servos, small motors, potentiometers, and gear trains. Widths are significantly narrower than standard to allow more room for rotors and stators. *Available in 16 types and sizes.*

SIZES:	BORE	O.D.	WIDTH
Min.	.0550	.1875	.047
Max.	.1875	.4375	.1094

QUALITY PERFORMANCE . . .

is in direct relation to quality of production. *All New Hampshire bearings* are made to ABEC-7 tolerances or better. The result is *improved running qualities* for all users . . . at no extra cost! In addition, rigid quality control during manufacture and continuing research enables New Hampshire to maintain leadership in our field . . . to supply you with the finest bearings for your needs at the lowest cost.

IMMEDIATE DELIVERIES FROM STOCK . . .

(For research & development, prototypes, and replacements) are made from our three regional offices as well as the main plant. Bearing specialists are on hand to help you plan and specify. Call your nearest office collect for fast service.

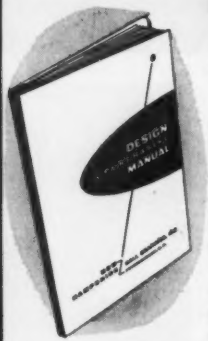
NEW HAMPSHIRE BALL BEARINGS, INC.

51 Cutter Mill Road
GREAT NECK, NEW YORK
HUnter 2-8633 TWX: 1421U

566 Northwest Highway
DES PLAINES, ILLINOIS
VAnderbilt 7-6646 TWX: 1642U

1540 North Highland Avenue
HOLLYWOOD 28, CALIFORNIA
HOllywood 4-0208 TWX: LA 933U

(main plant)
PETERBOROUGH, NEW HAMPSHIRE
WAlnut 4-3311 TWX: 209U



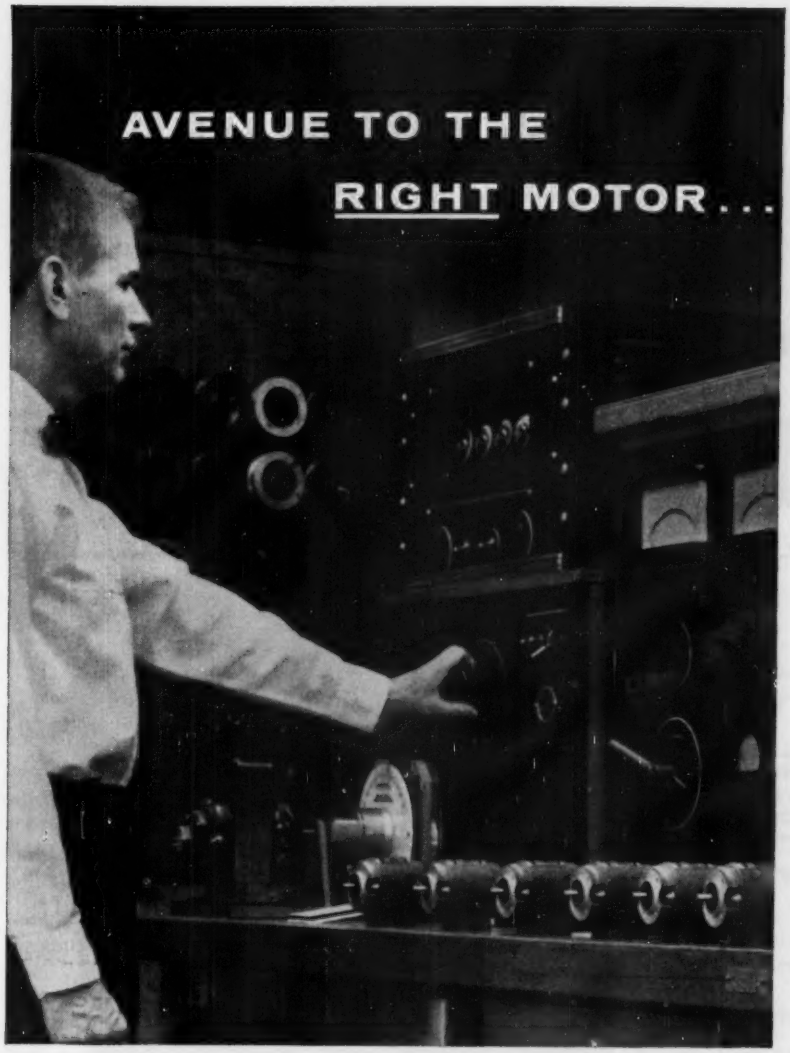
NEW DESIGN MANUAL

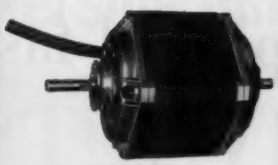
Newly revised and expanded, this authoritative publication is a guide to designing around, specifying and purchasing of miniature and instrument ball bearings. Comprehensive general information, catalog data, and engineering bulletins are included in the 100-plus pages. A personally registered copy is available to qualified engineers, draftsmen, and purchasing departments.

For your free Design and Purchasing Manual, write or call any New Hampshire Office.

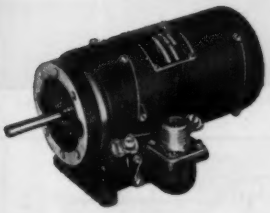
NEW HAMPSHIRE BALL BEARINGS, INC.

PETERBOROUGH, N. H.





Four-pole permanent split capacitor motor for business machines. Frame 2½ square x 1¾



Totally enclosed fan-cooled 27 volt DC motor for pump drive. Frame 2 x 1½

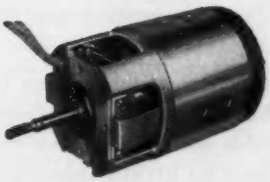
⅞ Horsepower motor with two-stage fan, Underwriters' labeled for explosion-proof vacuum cleaners.

Rigid and detailed testing assure desired performance

Thorough study by our engineering department of your product and its operating conditions enables us to design a Lamb® motor that will meet your exact requirements.

After rigid and detailed testing, we then mass produce the motor to obtain the most favorable cost.

May we discuss these advantages of Lamb motors with you?



24 Volt DC motor for operation submerged in jet fuel for booster pump drive. Frame 4 x 1½

WRITE FOR YOUR COPY...
8-page folder describes these and other Lamb Electric motors.

Lamb Electric

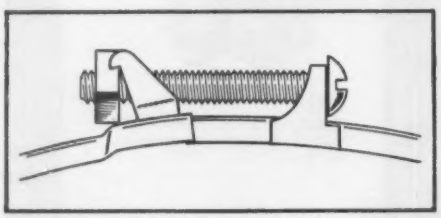
SPECIAL APPLICATION FRACTIONAL HORSEPOWER **MOTORS**

THE LAMB ELECTRIC COMPANY • KENT, OHIO
A Division of American Machine and Metals, Inc.
In Canada: Lamb Electric — Division of Sangamo Company Ltd. — Leaside, Ontario

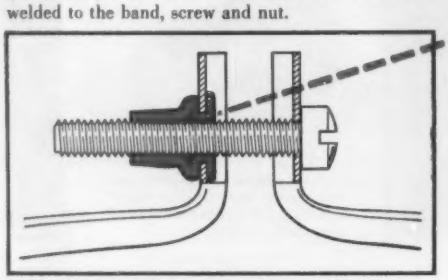
Circle 450 on Page 19

B.F.Goodrich

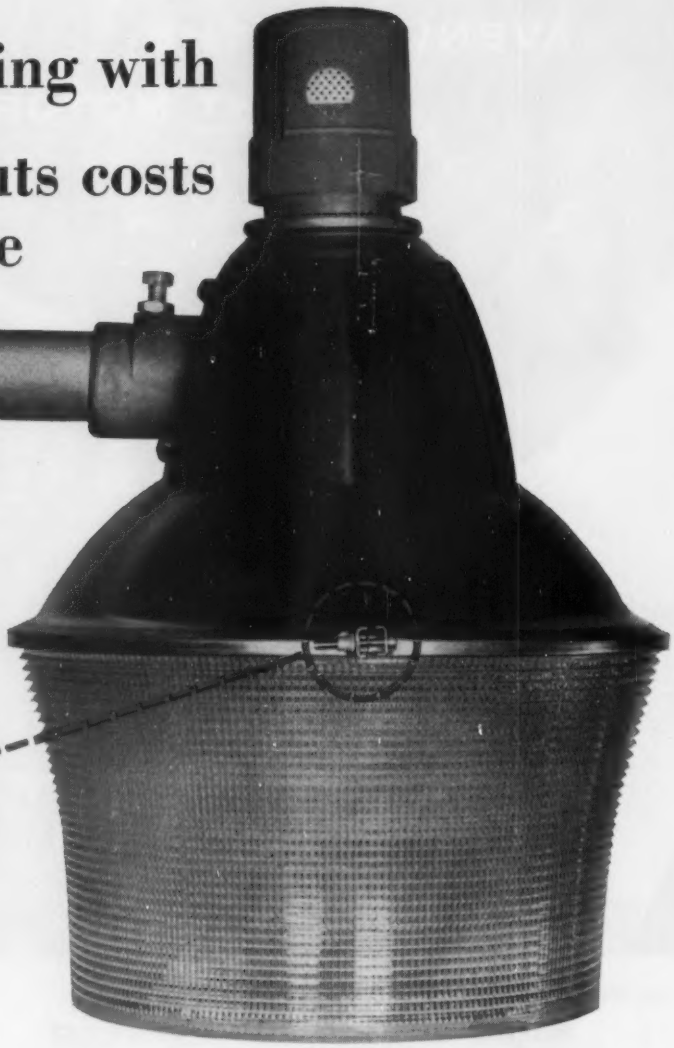
Improved fastening with RIVNUTS® cuts costs on new luminaire



OLD METHOD—This luminaire band assembly required five parts: the band, two stainless steel holders welded to the band, screw and nut.



RIVNUT METHOD—Redesigned assembly eliminates two parts. No welding operations required.



The manufacturer of this outdoor lighting luminaire, Line Material Industries, McGraw-Edison Company, reports "considerable cost savings" since redesigning the luminaire holding band for RIVNUT fastening.

Five separate spot welds were eliminated, along with two parts. The RIVNUT is strong and secure. And unlike the old method, there's no loose nut to be dropped.

RIVNUTS are the only one-piece blind rivets with internal threads. They can be installed by one person, from one side of the work, in a few seconds with a heading tool. If you'd like recommendations on a specific fastening problem, please send a print of your part.

You can improve fastening in sheet metal, tubing, tanks with RIVNUTS

New data booklet describes principle, typical applications of RIVNUTS, lists size and tool data. For free copy write Dept. MD-3B, *B.F.Goodrich Aviation Products, a division of The B.F.Goodrich Company, Akron, Ohio.*

B.F.Goodrich *Rivnuts*

TUTHILL automatic reversing pumps

- **Positive reversing action**
- **Require no valves**
- **Port positions remain constant**

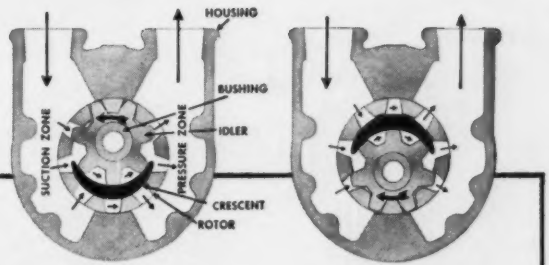
The model RCK above is typical of Tuthill's complete line of automatic reversing pumps . . . which use the time tested operating principle at the right to provide instantaneous, positive reversing action without the use of valves. The port positions remain constant regardless of the direction of shaft rotation. And all pumps provide uniformly high efficiency in both flow directions.

The automatic reversing design was developed by Tuthill for applications where the pump must be driven from a reversing shaft, or where machinery must be shipped without knowing the ultimate direction of the driving unit. These pumps have been enthusiastically accepted by designers and have proven their dependability in thousands of demanding applications such as large air compressors and machine tools.

375 Models

A complete selection of 375 models is provided with capacities from ⅓ to 200 gpm; for pressures to 400 psi; and speeds to 1800 rpm. Included are a complete assortment of stripped models specially developed for incorporation into manufactured products.

A 12-page catalog, No. 105, gives complete information on all Tuthill automatic reversing pumps. Write today for your copy. Or, if you desire, send drawings so that Tuthill's engineers can show you how the Model R reversing pump can be built directly into your product.



COUNTER-CLOCKWISE ROTATION

CLOCKWISE ROTATION

THE PUMPING PRINCIPLE

Tuthill automatic reversing pumps are based on the use of a rotor, idler gear and a crescent shaped partition which is integral with a moving part called the Idler Carrier.

Figure 1 shows how power is applied in counter-clockwise rotation to the rotor and transmitted to the idler gear with which it meshes. The space between the outside diameter of the idler and the inside diameter of the rotor is sealed by the crescent. When the pump is started there is an increase in volume as the teeth come out of mesh. This creates a partial vacuum, drawing the liquid into the pump through the suction port. The liquid fills the spaces between the teeth of the idler and rotor and is carried past the crescent partition to the pressure side of the pump. When the teeth mesh on the pressure side, the liquid is forced from the spaces and out through the discharge port.

When the shaft rotation changes from counter-clockwise to clockwise, the idler carrier (including the idler gear and crescent) automatically rotates 180° through the suction zone to the position shown in Figure 2 which *changes the direction of flow within the pump* without changing port positions. The idler carrier rotates in a cover casting fitted with stops so that the crescent can rotate only 180°—always through the suction zone. Upon resumption of counter-clockwise rotation, the crescent will swing back to the original position in Figure 1.

Tuthill Manufactures a Complete Line of Positive Displacement Rotary Pumps in Capacities From ⅓ to 200 GPM; for Pressures to 1500 PSI; speeds to 3600 RPM.

PUMPS FOR YOUR PURPOSE

TUTHILL PUMP COMPANY

953 East 95th Street, Chicago 19, Illinois

NFPA NATIONAL FLUID POWER ASSOCIATION

Circle 452 on Page 19

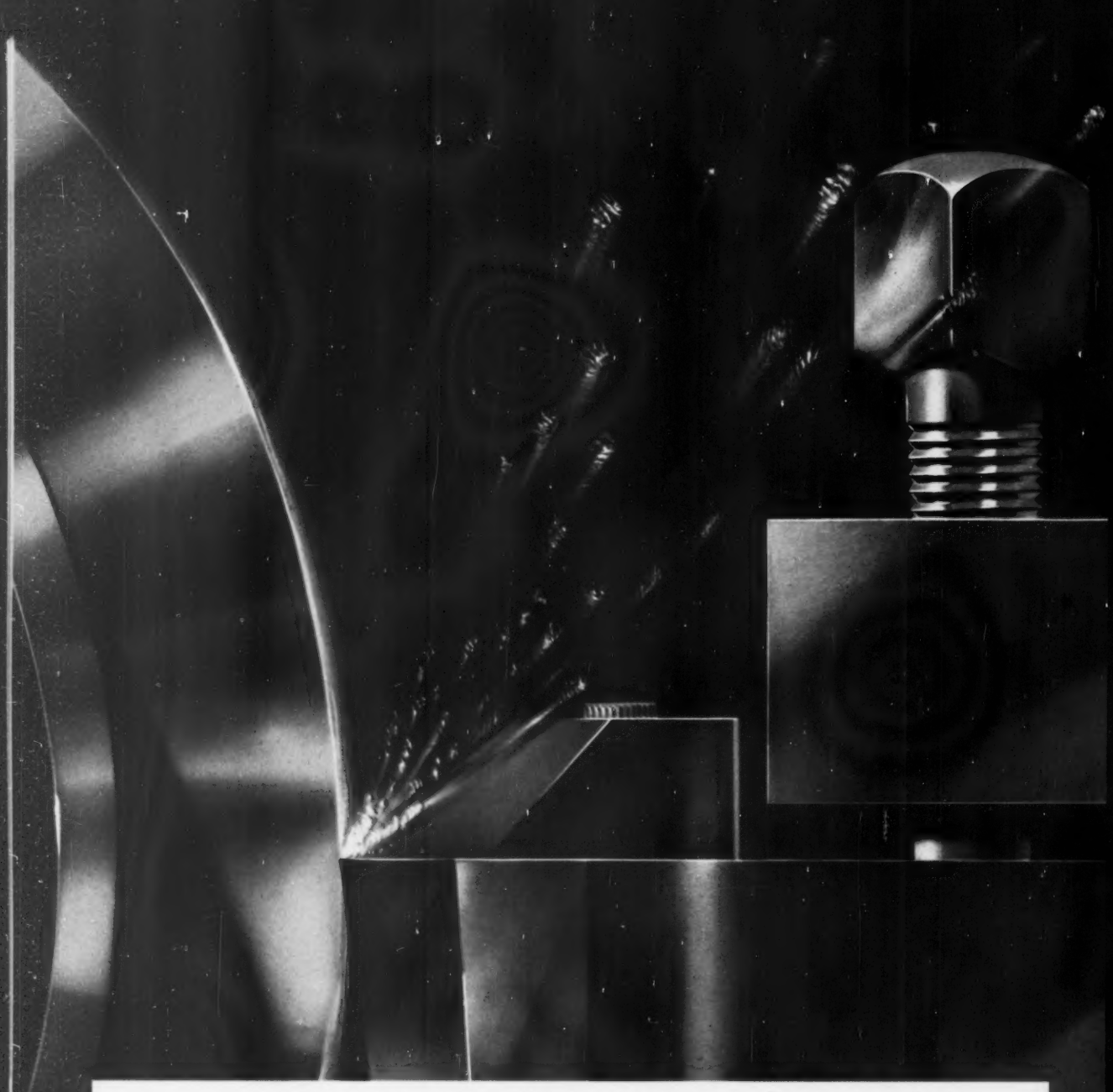


Illustration of Malleable casting being turned at 1,400 surface feet per minute with a 0.100" depth of cut using an oxide tool.

Cut Machining Time and Costs... Use Malleable

It's the **finished** cost of machined components that's important to you. Remember then . . . Malleable iron is the most readily machinable of all ferrous metals of similar properties. With Malleable castings you'll reduce machining time as much as 50% . . . increase tool life up to 250% . . . get unexcelled surface finishes.

Find out how much you can cut **your** finished parts costs. Contact any nearby Malleable castings producer who displays this symbol—

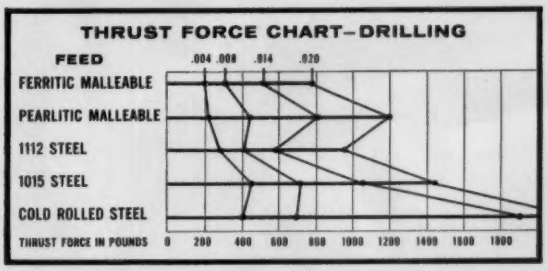
MEMBER
MALLEABLE
CASTINGS COUNCIL

For detailed information on "Machinability of Malleable Castings", contact any of the progressive companies listed on the opposite page, or Malleable Castings Council, Union Commerce Building, Cleveland 14, Ohio.

You'll Get Faster Machining...Better Finished Surfaces... Longer Tool Life with Malleable Castings

Whatever your machining goals—reduced cycle times, lower tool costs or better surface finishes, you will profit from remembering this fact: Malleable is the most machinable of all ferrous metals of comparable properties.

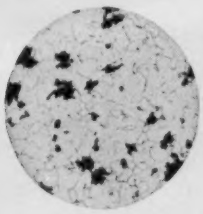
For example, compare the force required to drill Malleable with that required to drill other commonly used metals as we have done here—



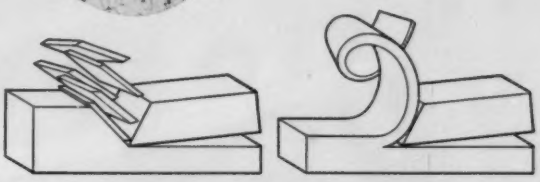
For this test we used ½ inch high speed steel twist drills with a suitable lubricant and a spindle speed of 715 RPM. AISI 1112 steel (Bessemer screw stock) was included because it is often used as a standard for machinability comparisons. Since machining may cost 2 to 4 times as much as the rough parts, the superior machinability of Malleable iron, as demonstrated here, can result in very large savings.

Chips Reveal the Secret of Malleable's Machinability

In addition to providing strength and ductility, Malleable's internal structure of microscopic carbon nodules allows Malleable to break easily into small chips as it is machined. This kind of Type I chip is highly desirable. Speeds and feeds can be increased . . . power consumption drops . . . cutting tools last longer. Malleable's uniform structure permits safe machining at maximum speeds.



Spherical carbon nodules (black) help break up chips. Photomicrograph 50X, etched.



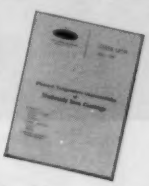
Schematic drawing illustrates how Malleable (left) breaks into short, discontinuous Type I chips, rather than long, continuous Type II and III chips (right).

Future Promises New Triumphs for Malleable

With over two years' experience in advanced machining research, forward-looking Malleable castings producers already know how Malleable will perform when oxide cutting tools come into wide use. In experiments like the one illustrated on the opposite page it has been demonstrated that Malleable can be successfully machined at speeds as high as 1400 surface feet per minute and a 0.100" depth of cut! Surface finish, tool life and metallurgical structure are excellent . . . All this in a metal of rugged engineering properties.

Prove for yourself how much Malleable's machinability will do for your products . . . and your profits. Get in touch with one of the Malleable castings producers listed below. Call today.

Send for Free Machining Information A special folder, *Data Unit 106, Machining Malleable Iron Castings,* is available from the Malleable Castings Council, Union Commerce Building, Cleveland 14, Ohio, or from any member company.



For Quality and Economy...Use MALLEABLE

For Service In Your Area Contact...

CONNECTICUT
Connecticut Mall. Castings Co., New Haven 6
Eastern Malleable Iron Co., Naugatuck
New Haven Malleable Iron Co., New Haven 4

DELAWARE
Eastern Malleable Iron Co., Wilmington 99

ILLINOIS
Central Fdry. Div., Gen. Motors, Danville
Chicago Malleable Castings Co., Chicago 43
Moline Malleable Iron Co., St. Charles
National Mall. and Steel Castings Co., Cicero 50
Peoria Malleable Castings Co., Peoria 1
Wagner Castings Company, Decatur

INDIANA
Albion Malleable Iron Company, Muncie Division, Muncie
Link-Belt Company, Indianapolis 6
National Mall. & Steel Castings Co., Indianapolis 22

IOWA
Iowa Malleable Iron Co., Fairfield

MASSACHUSETTS
Belcher Malleable Iron Co., Easton

MICHIGAN
Albion Malleable Iron Co., Albion
Auto Specialties Mfg. Co., Saint Joseph
Cadillac Malleable Iron Co., Cadillac
Central Fdry. Div., Gen. Motors, Saginaw

MINNESOTA
Northern Malleable Iron Co., St. Paul 6

MISSISSIPPI
Mississippi Malleable Iron Co., Meridian

NEW HAMPSHIRE
Laconia Malleable Iron Co., Laconia

NEW YORK
Acme Steel & Mall. Iron Works, Buffalo 7
Frazer & Jones Company Division, Eastern Malleable Iron Co., Solvay
Oriskany Malleable Iron Co., Inc., Oriskany
Westmoreland Mall. Iron Co., Westmoreland

OHIO
American Malleable Castings Co., Marion
Central Fdry. Div., Gen. Motors, Defiance
Dayton Mall. Iron Co., Ironton Div., Ironton
Dayton Mall. Iron Co., Ohio Mall. Div., Columbus 16
Maumee Malleable Castings Co., Toledo 5
National Mall. and Steel Castings Co., Cleveland 6

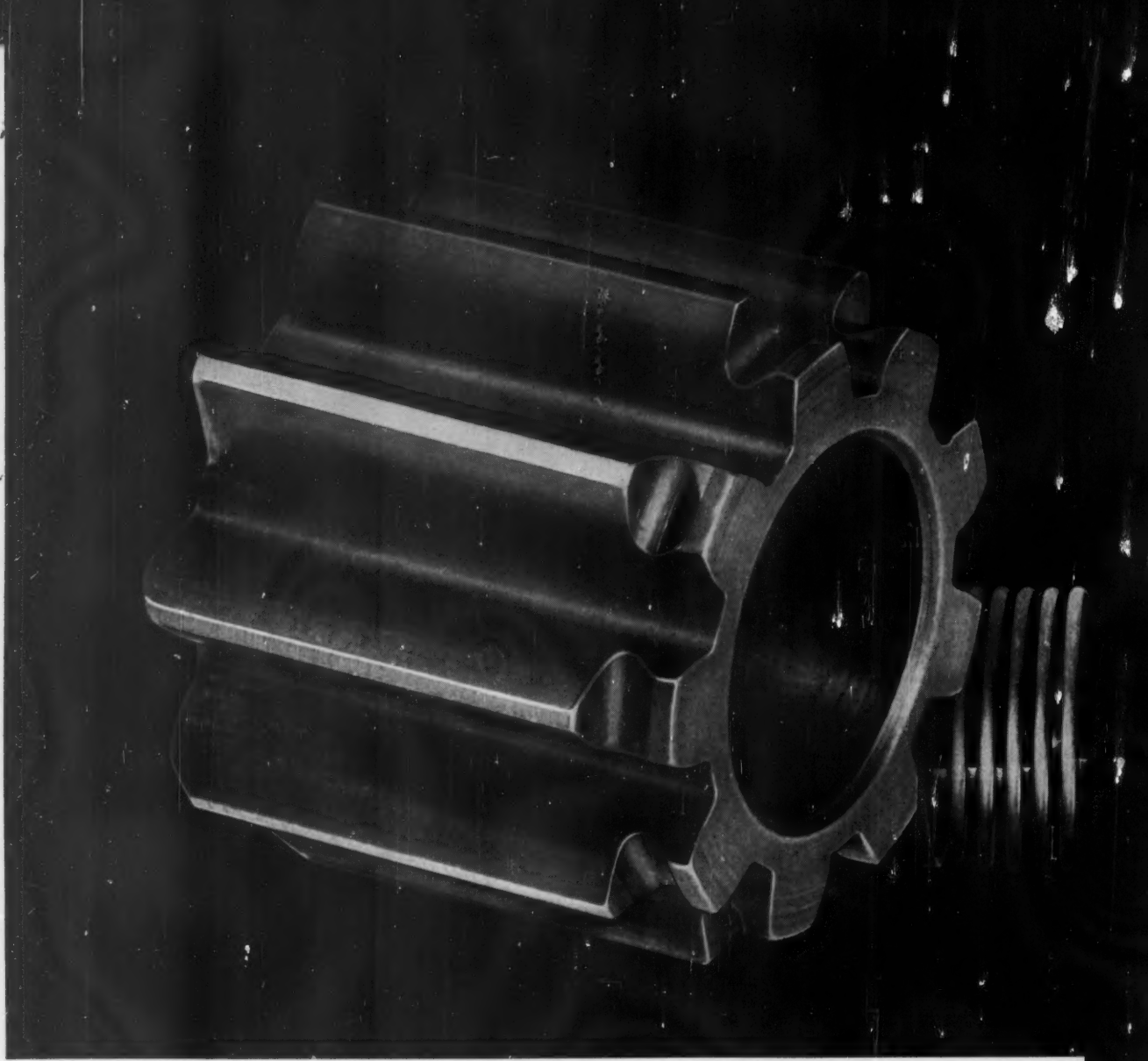
PENNSYLVANIA
Buck Iron Company, Inc., Philadelphia 22
Erie Malleable Iron Co., Erie
Lancaster Malleable Castings Co., Lancaster
Lehigh Foundries Company, Easton
Meadville Malleable Iron Co., Meadville
Pennsylvania Malleable Iron Corp., Lancaster

TEXAS
Texas Foundries, Inc., Lufkin

WEST VIRGINIA
West Virginia Mall. Iron Co., Point Pleasant

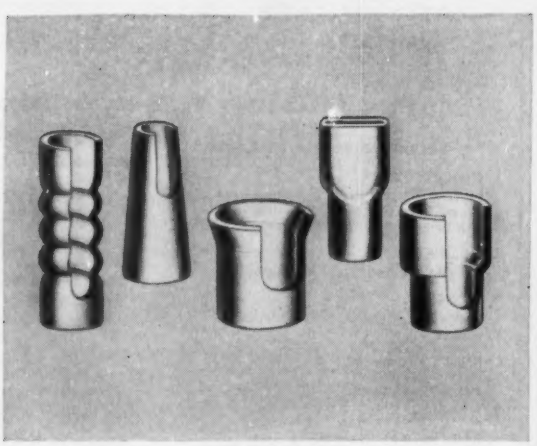
WISCONSIN
Belle City Malleable Iron Co., Racine
Chain Belt Company, Milwaukee 1
Federal Malleable Company, Inc., West Allis 14
Kirsh Foundry Inc., Beaver Dam
Lakeside Malleable Castings Co., Racine
Milwaukee Malleable & Grey Iron Works, Milwaukee 46

Circle 453 on Page 19



ONE-PIECE SHAPES REPLACE COSTLY ASSEMBLIES when Republic Cold Drawn Special Section Bars formed to the predominating cross section of the part are used. Completed parts are stronger, longer wearing, and cost less. Republic Special Sections simplify built-up, interlocking, or associated parts . . . are available in carbon, alloy, and stainless steels.

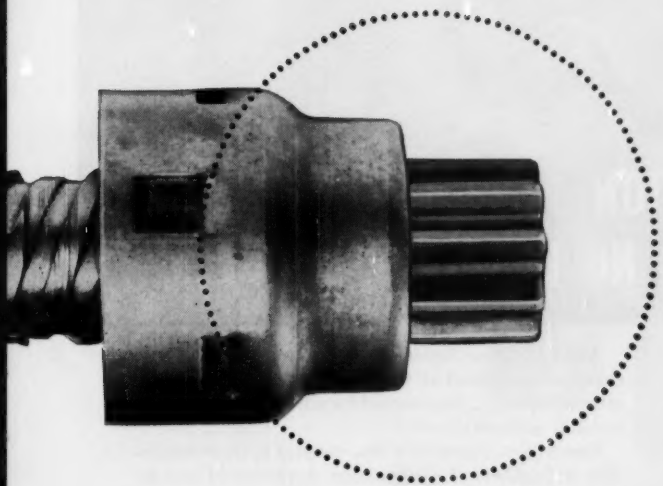
Circle 454 on Page 19



SIMPLIFIED TUBULAR PARTS PRODUCTION results from use of Republic ELECTRUNITE® Mechanical Tubing. With uniform wall thickness, concentricity, strength, and ductility, ELECTRUNITE Round Mechanical Tubing is easily flanged, swaged, flattened, spun, fluted, configured, rolled, upset, and otherwise changed in cross section. Mail coupon.

Circle 455 on Page 19

SOLVING THE PROBLEM



Alloy steel starter drive pinion withstands severe torque, impact, wear

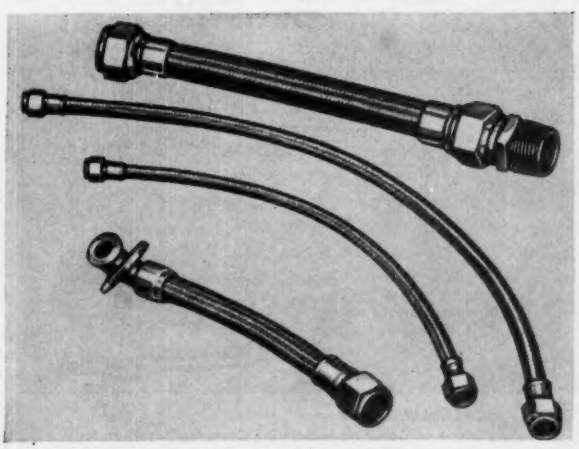
One of the largest manufacturers of automobile starter drives specifies Republic Cold Drawn Alloy Steel Bars for their most critical component—the drive pinion. *Circle 457 on Page 19*

Following delivery, the cold finished alloy bars are blanked, hobbed, chamfered, and drilled. Teeth are cut on a gear hobber, then pointed for easy meshing with the flywheel.

Use of Republic Alloy Steel provides the necessary strength and toughness to withstand torque, impact, and prolonged wear. In addition, the cold drawn alloy used provides better machinability at reasonable cost.

Republic field metallurgists will work closely with your metallurgists and engineers. 3-Dimensional Metallurgical Teams, comprised of field, mill, and laboratory metallurgists, will help you select, apply, and process the right alloy steel for any application. Write today or mail the coupon for complete information—without obligation—on this confidential service.

Circle 458 on Page 19



HIGH PRESSURE FITTINGS—sockets, nipples, flanges, elbows, and swivel nuts—to handle missile and aircraft fuels are produced by Resistoflex Corporation, Roseland, New Jersey. Fittings are machined from ⅜″ and 2″ diameter Republic Stainless Steel Bars to assure maximum strength, corrosion-resistance, and machinability.

Circle 456 on Page 19

REPUBLIC STEEL

World's Widest Range of Standard Steels and Steel Products

REPUBLIC STEEL CORPORATION
DEPT.MD-8187-A
1441 REPUBLIC BUILDING • CLEVELAND 1, OHIO

Send more information on:

- ☐ Cold Finished Stainless Steel Bars
- ☐ Cold Finished Alloy Steel Bars ☐ Special Bar Sections
- ☐ 3-Dimensional Metallurgical Teams
- ☐ ELECTRUNITE Mechanical Tubing

Name_____ Title_____

Company_____

Address_____

City_____ Zone____ State_____

NEW!

SCHRADER INDUSTRY-INTERCHANGEABLE HI-FLO* AIRLINE COUPLER!

SAFE PUSH-PULL OPERATION
ACCIDENTAL UNCOUPLING NO LONGER A PROBLEM!

Schrader's new quick-acting couplers are full of features that afford the best air service. Safety's built in . . . it won't open accidentally even when dragged on the ground and snarled on a piece of machinery . . . yet the heavily knurled new coupler connects and disconnects in a single upstream push or pull with *one hand, gloved or greasy!*

More features: fastest air flow . . . non-corrosive . . . case hardened steel all through . . . meets and exceeds military specs . . . engineered for simple, easy replacement of parts in the field.

Important: Schrader's new coupler is interchangeable with others of similar type. A variety of end fitting styles are available. See your supplier soon.

NEW COUPLER CHECK UNITS AND ADAPTERS

#5139-12–¼ N.P. FEMALE

#5138-12–¼ N.P. MALE
#5140-12–⅜ N.P. MALE

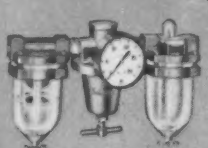
#5138-11–¼ N.P. MALE

#5139-11–¼ N.P. FEMALE

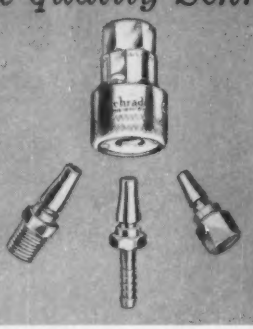
#5140-11–SERRATED SHANK FOR ⅜ I.D. HOSE

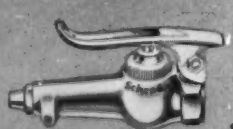
. . . added to these quality Schrader Accessories

SCHRADER HOSE REELS work like window shades. Tuck hose away automatically. No. 3481 is Air Tool Suspension Type.



SCHRADER LUB-AIR-ATOR does 3-way jobs: filters, lubricates, regulates. Keeps systems operating smoothly.





SCHRADER LEVER TYPE BLOW GUN offers precision control, from a gentle puff to a full blast.

SCHRADER BUTTON TYPE BLOW GUN is all-purpose, easy-operating, with durable forged brass body.

SCHRADER STANDARD COUPLERS WITH FASTER FLOW are now being shipped.

*Reg. U. S. Pat. Off.

Schrader®
a division of **SCOVILL**

A. SCHRADER'S SON
Division of Scovill Manufacturing Company, Incorporated
476 Vanderbilt Avenue, Brooklyn 38, N. Y.

QUALITY AIR CONTROL PRODUCTS

Circle 459 on Page 19

WHO MAKES FINE MOTORS THIS SMALL?

Globe Industries makes motors this small to make your design more compact, reliable and salable. If you make miniature instrument packages for space exploration — if you build airborne and ground support equipment—if you want to design smaller typewriters, computers, recorders or other products, look at these 3 motors:

TYPE VS—The smallest, most powerful precision miniature d.c. motor for its size. Only 7/16" flat, four VS motors fit in a regular cigarette pack with room to spare. It has the power to lift its own weight to the top of the Empire State Building in 1 minute! Typical continuous torque—.25 oz. in.; typical intermittent torque—.5 oz. ins. We can design gear units, governors and brakes to meet MIL specs also.

TYPE SS — Only 7/8" in diameter, Type SS d.c. motors typically produce continuous duty torques of .3 oz. in.; intermittent torques to .6 oz. ins. With the basic Type SS motor you can specify any of 21 planetary gear speed reducers or 28 spur gear speed reducers. Governors and brakes are available also. Designed to meet MIL specs.

TYPE MM — The most widely used precision 1¼" d.c. motor in the world, MM motors typically produce .5 oz. in. in continuous duty applications — 1.0 oz. in. intermittent duty. Choose from 101 ratios of planetary gear speed reductions. Brakes, governors and clutches can be included. MIL specs are invited.

For details about these motors request Bulletin VSM. Globe Industries, Inc., 1784 Stanley Ave., Dayton 4, Ohio.

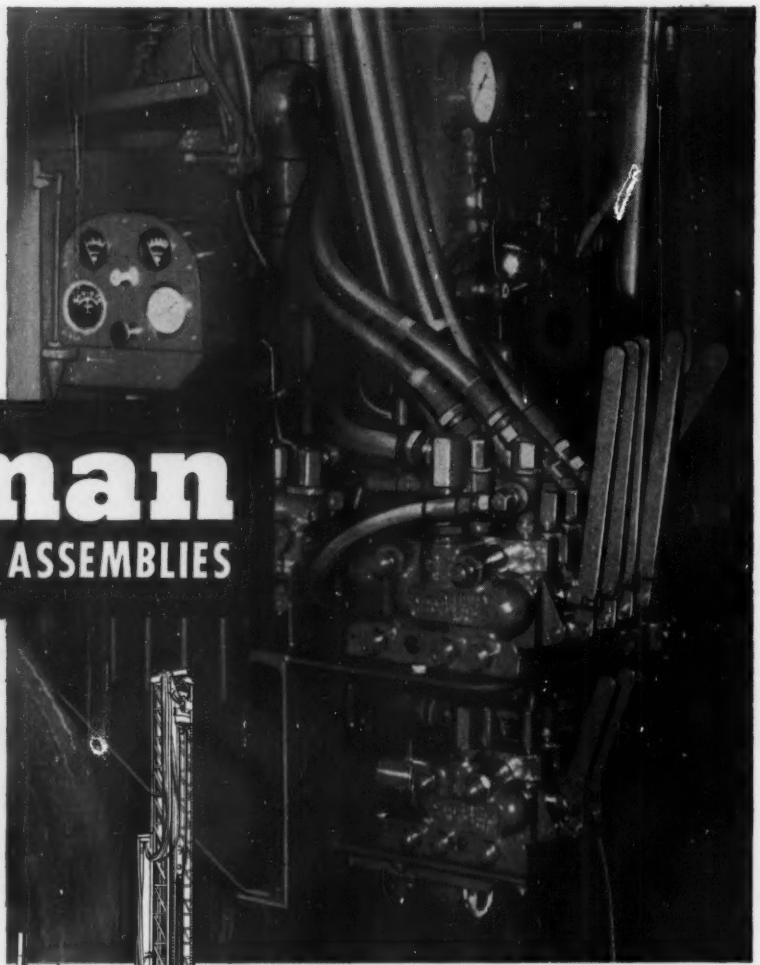
GLOBE INDUSTRIES, INC.

PRECISION MINIATURE A.C. & D.C. MOTORS, ACTUATORS, TIMERS, GYROS, STEPPERS, BLOWERS, MOTORIZED DEVICES

GLOBE

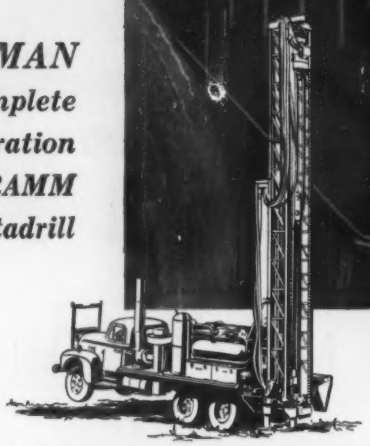
Circle 460 on Page 19

THE KEY TO A DEPENDABLE SYSTEM!



Eastman
HYDRAULIC HOSE ASSEMBLIES

EASTMAN designs complete hydraulic operation for SCHRAMM Rotadrill



Valves mounted in three convenient banks for each outrigger, forward and reverse rotation of motor, slow down speed, rapid down speed and for breakout cylinder.

The cooperation of EASTMAN Engineering was enlisted in making the operation of this truck-mounted Schramm Rotadrill *completely hydraulic.*

Hydraulic power is delivered through EASTMAN Hydraulic Hose Assemblies to:

1. Three-Speed Reversible Rotation Head: Standard speeds—44, 65 and 120 r.p.m. with 26,500 inch pounds torque. 2. Cylinders controlling down feed, rapid feed and slow feed. 3. Controls for raising and lowering of mast. 4. Breakout Cylinder. 5. Hydraulic Winch and Hook. 6. Three Outriggers.

Dependable field service is assured through EASTMAN Two-Wire Braid High Pressure Hose with Permanently Attached Couplings providing a bond stronger than the hose itself.

Efficient power delivery through the extensive, multiple circuits of this rock-drilling rig is obtained through EASTMAN designed permanently attached hose assemblies which insure longer life and lower cost.

ENGINEERED FOR ENGINEERS BY ENGINEERS

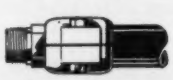
Let EASTMAN Engineering assist you in planning the initial layout of your hydraulic system—for most efficient power delivery and lowest cost.

Eastman MANUFACTURING COMPANY
Dept. MD-3, MANITOWOC, WISCONSIN

PERMANENTLY ATTACHED COUPLINGS
for 1, 2, and 3 wire braid rubber cover hose

REUSABLE COUPLINGS
for fabric cover hose

REUSABLE COUPLINGS
for rubber cover hose



CLAMP COUPLINGS
for 1, 2, and 3 wire braid rubber cover hose

Write today for Bulletin 100 and 200 on EASTMAN High, Medium and Low Pressure Hydraulic Hose Assemblies.

Whatever your design problem there is a

Faultless Caster

to solve it!

Design Problem:
Shimmyless, Quiet-running Caster for Hospital Carts and Stretchers

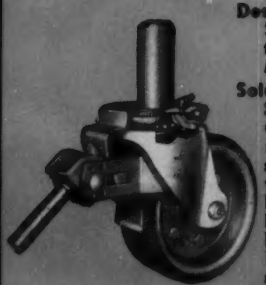
Solution:
Series 2400 Medium Duty Swivel Stem Truck Caster. Hardened ball bearings running in 2 raceways machined to closely held tolerances. Precision adjustment of swivel assembly elimates troublesome wobbling of ordinary kind. 5", 8" or 10" dia. wheels for smooth, noiseless rolling.

Design Problem:
V-Grooved Wheel to Follow Angle Iron Tracks

Solution:
Light, medium and heavy duty casters are available with 4" to 10" V-Grooved Wheels to carry loads from 325 lbs. to 15,000 lbs. along unobstructed tracks. Save floor surfaces, eliminate noise and vibration. V-Grooved Wheels have flat outer treads for use on floors.

Design Problem:
Cushion Action Caster for Level Ride over Irregular Floors

Solution:
Series SH300 Spring Action Swivel Plate Truck Caster eliminates bounce. Caster maintains continual floor contact. Durable, long-lasting spring and draw bars, on center line of wheel, absorb shock and lengthen life of ball bearings, raceways and wheels.



Design Problem:
Scaffold and Platform Caster that Double Locks against Movement

Solution:
Series C900 Scaffold Caster has Brake that simultaneously locks both swivel and wheel. Scaffold will not creep. Foot or hand operated brake lever locks in up position . . . releases in down position. Large diameter wheel for smooth rolling over ordinary obstacles.

Design Problem:
Sealed Caster Bearings for Use in Extreme Temperatures or Moisture-laden Air

Solution:
Series 900 GS Swivel Plate Truck Caster has built-in protective grease seals around main load, thrust and wheel bearings. Exclude water, chemicals, dirt. Prevent grease leaking to floor, assure easy maintenance, low upkeep.

Design Problem:
Exciting, All-New Caster Concept To Enhance Your New Furniture Line

Solution:
Royal-Roll, the "King of Casters" combines unique styling and time-tested furniture caster engineering. Double ball bearing swivel, non-marking wheel and hooded horn. Spherical black wheel with bright nickel or brass horn. Stems for wood, tubular metal and cast legs.

For FREE Condensed Catalog, or more information on specific Casters, fill out coupon today. Or contact your nearby Faultless Distributor who is listed in classified directory under Faultless heading.

Tell me more about:

- ☐ Series 2400
- ☐ V-Grooved Wheel
- ☐ Series SH300
- ☐ Series C900
- ☐ Series 900 GS
- ☐ Royal Roll

Faultless Caster Corporation
Evansville 7, Indiana

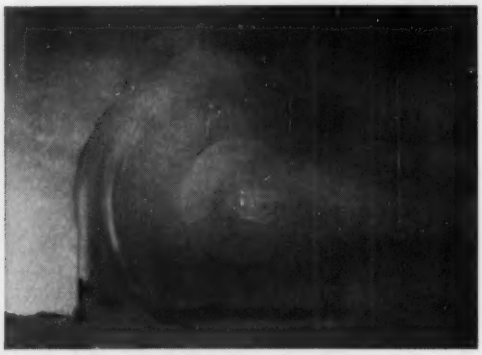
Name _____

Title _____

Company _____

City _____ State _____

PICKLED in a 4% brine solution!



CHOKED
in a tornado of abrasive dust!

FROZEN
for weeks at 75° C below zero!

BURIED ALIVE
in thick, sluggish mud!

nothing . . . but nothing stops Super-Seal open-type motors

Thanks to exclusive Poxeal and Silco-Flex insulations, Super-Seal motors have shown endurances that even enclosed motors couldn't match. Results and reasons available from your A-C representative or distributor. Or write General Products Division, Milwaukee 1, Wisconsin

Poxeal, Silco-Flex and Super-Seal are Allis-Chalmers trademarks.

ALLIS-CHALMERS A-C A-1151

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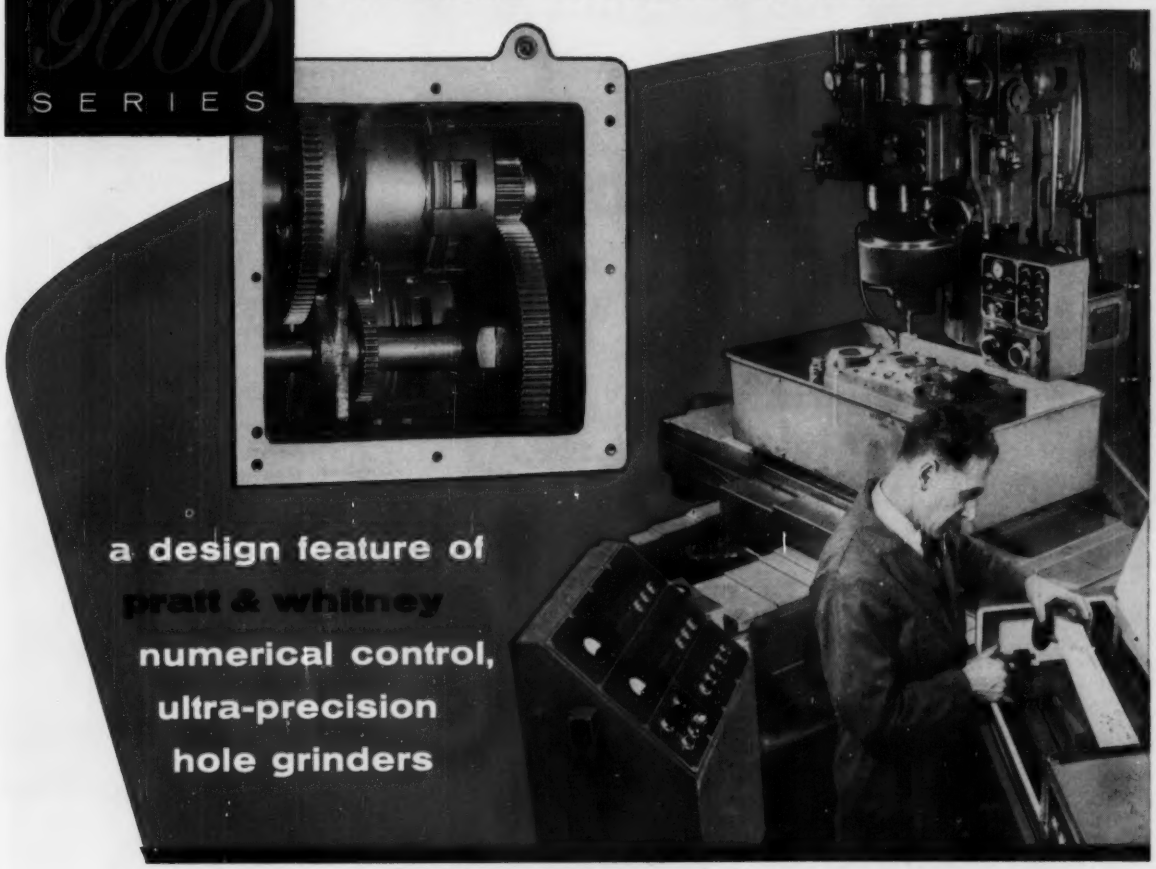
Maxitorq

electric clutches and brakes

9000 SERIES



Again a famous machine tool builder favors today's outstanding electric clutches and brakes

Previously, Pratt & Whitney incorporated MAXITORQ Clutches in their high-precision jig borers. Proved performance led their engineers to test and accept the new 9000 series MAXITORQ Electric Clutches for their latest development . . . the fully automatic, numerically controlled, ultra-precision Vertical Hole Grinder and Electrolimit Jig Borers. Inset photograph above shows the compact and "clean" installation of two of these clutches in the carriage control drive gear box.

Incorporating new and advanced design principles, the 9000 Series MAXITORQ Electric Clutch is well adapted to machine tool drives. It is simple in design . . . built to machine tool standards . . . requires no adjustments. It can be used *either as a clutch or brake*. Disc separators not only separate discs but also break up residual magnetism, and result in extremely fast, positive action with no drag or heating in neutral. Design principles have been PROVED through years of service. There are few moving parts. Electrical operating unit remains stationary—hence, there are no troublesome slip rings or brushes; no difficult wiring problems. Clutches operate on standard 110 V a.c. converted to 90 V d.c. Other voltages on special order.

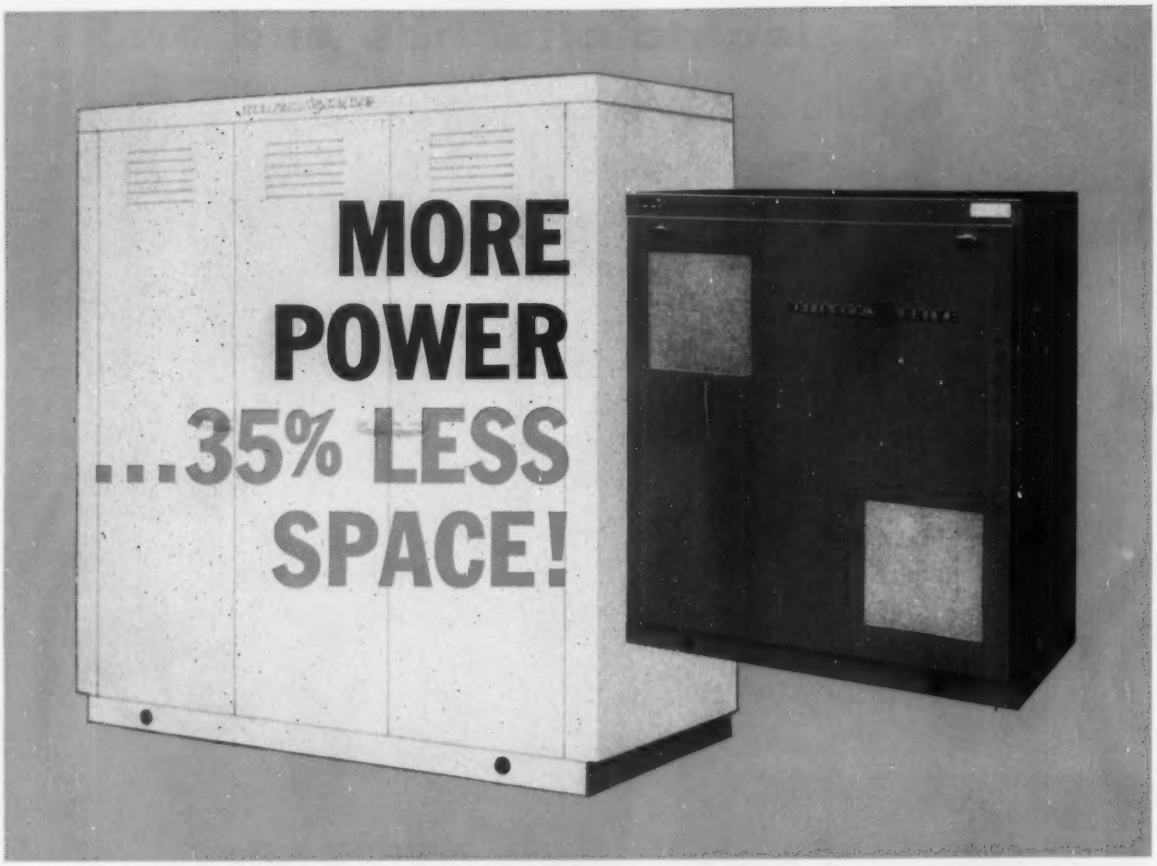
If you have a clutch or brake application where you are looking for NEW and IMPROVED performance, we invite you to bring the problem to us.

Phone, wire or write Dept. ***MD-3*** *for new #9000 Series bulletin*

6CJ88

The Carlyle Johnson Machine Company, Manchester, Conn.

Reliance Super 'T' V★S Drives



Both of these control units are rated at 50 horsepower! Actually, the new, small Super 'T' V★S cabinet packs more punch!

LIKE the Reliance Super 'T' Drive Motor, new V★S power units utilize Class B insulation, permitting a more compact unit. 100% overloads of one minute duration are accomplished without failure! Advanced design of ventilation keeps control and power units cooler . . . another reason why smaller size is possible. And service life is substantially extended.

Matched system design of drive motor, power unit and controls produces a highly efficient, integrated drive—to give you a wide range of stepless, variable operating speeds from a-c. circuits.

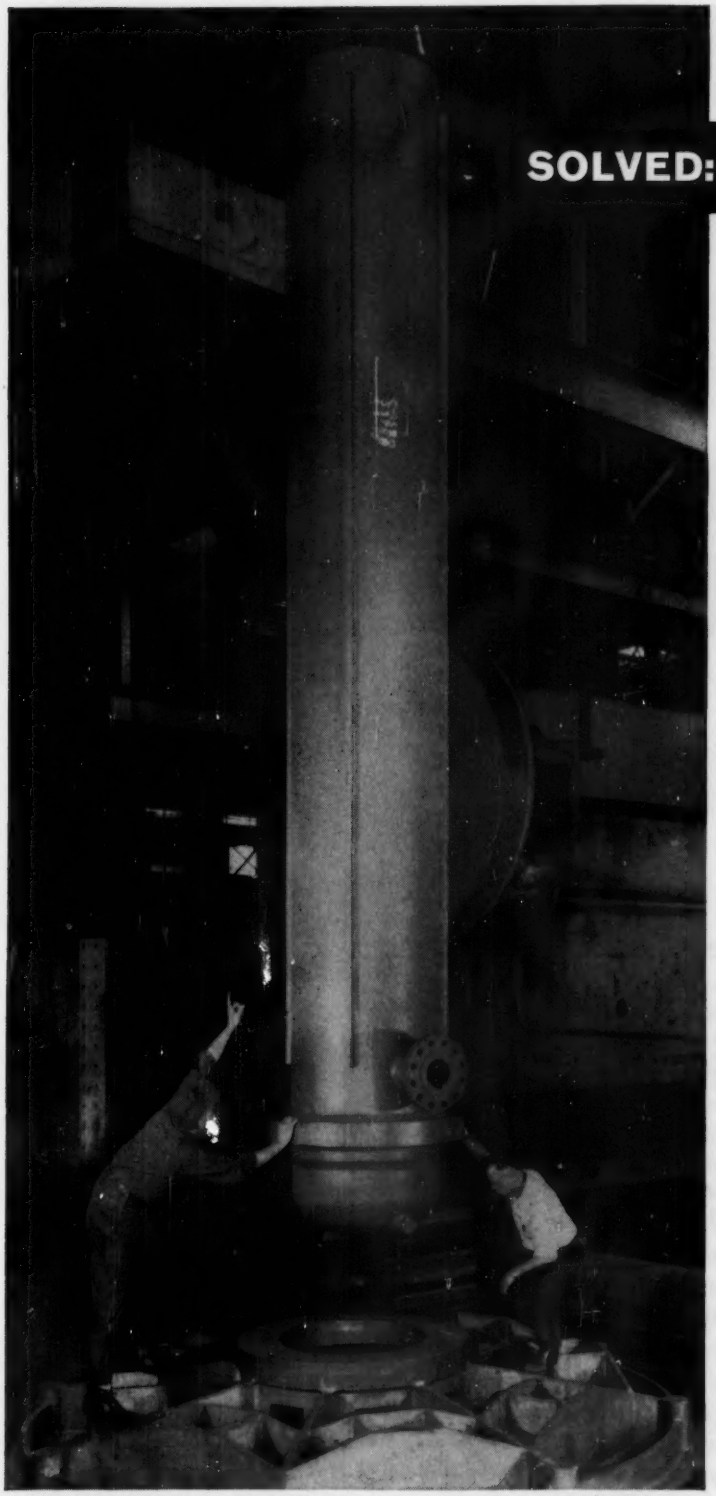
Super 'T' V★S Drives are available for immediate delivery. Check your Reliance salesman for delivery schedules on the full line, 1—350 hp., Bulletin Number D-2506, has been prepared to give you complete information. Write for it. D-1641

Product of the combined resources of Reliance Electric and Engineering Company and its Master and Reeves Divisions

RELIANCE ELECTRIC AND ENGINEERING CO.

DEPT. 283A1, CLEVELAND 17, OHIO
Canadian Division: Toronto, Ontario
Sales Offices and Distributors in principal cities

Duty Master A-c. Motors, Master Gearmotors, Reeves Drives, V★S Drives, Super 'T' D-c. Motors, Generators, Controls and Engineered Drive Systems.



Blaw-Knox workmen assembling one of two constant pressure type accumulators built for two of America's largest steel mills. Sandusky supplied the straight cylindrical sections for both.

SOLVED: by Sandusky Centrifugal Casting

Blaw-Knox chooses 10-ton SANDUSKY CASTING for giant slabbing mill

When an 18½-foot cylinder was needed for a new giant Universal slabbing mill built by Blaw-Knox Company's East Chicago (Indiana) Works for a well known steel mill, they found that the most practical and economical way to meet all requirements was with a Sandusky Centrifugal Casting.

This 10-ton carbon steel cylinder, 32" O.D. with a 3½" wall, functions as an accumulator in the mill's hydraulic roll balancing system. Essentially a pressure vessel, it simultaneously supports the ram and ballast weighing 226 tons—the weight required to develop constant operating pressure of 1000 p.s.i.

"Only a dimensionally stable, one-piece cylinder could perform satisfactorily in this service," a Blaw-Knox official asserted. *"Distortion could lead to binding, loss of pressure and costly down-time. Sandusky's ability to produce this heavy walled cylinder in one 18½ foot length met all our requirements of cost, stability, and strength."*

Sandusky cylinders up to 33 feet long —from 7" to 54" O.D.— and in a wide range of ferrous and non-ferrous alloys —may well be the answer to *your cylindrical problems*, too.

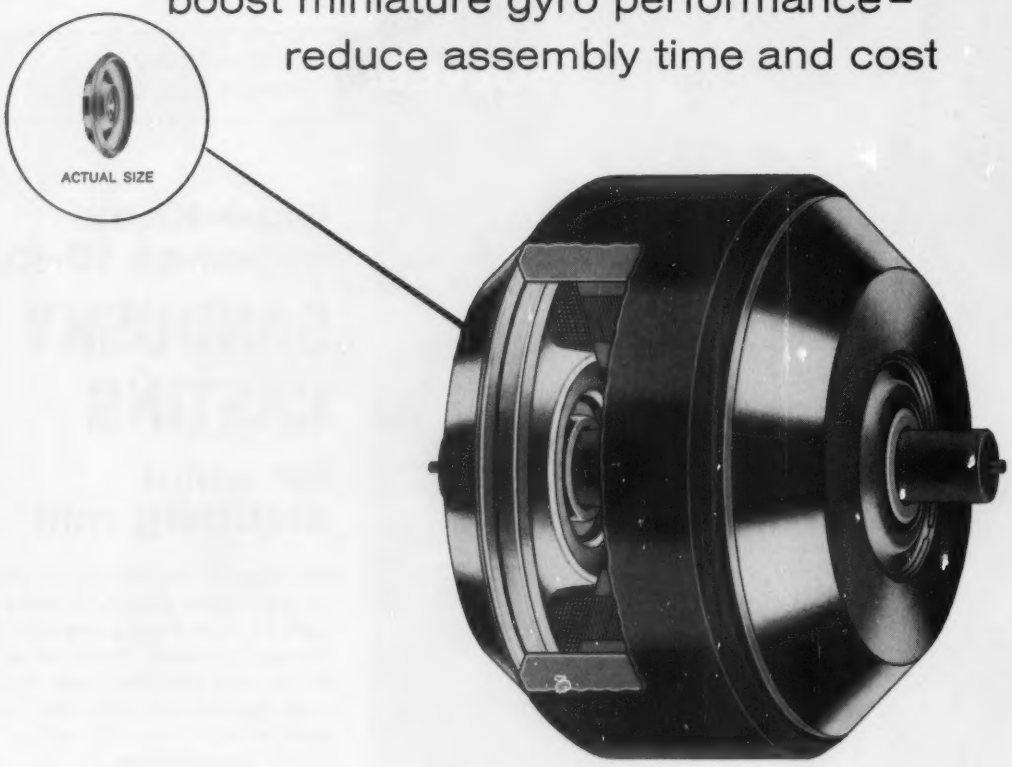
Write to us at Sandusky, Ohio. Ask for latest Bulletin #200.

SANDUSKY CENTRIFUGAL CASTINGS
FOUNDRY & MACHINE CO.

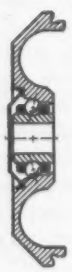
8301

SANDUSKY, OHIO—Stainless, Carbon, Low-Alloy Steels—Full Range Copper-Base, Nickel-Base Alloys

BARDEN end-bell bearings boost miniature gyro performance – reduce assembly time and cost



Integral design simplifies manufacture, reduces mating-part errors



Z155, *above and in main illustration*, is one of several Barden Precision end-bell bearings currently in volume production. Bore sizes range from .0781" to .1250" for through-bored rotor rings from .5751" to .9375" I.D. For complete technical information, write for Engineering Data Sheet Z-1.

Rotor bearings for miniature rate gyros in missile stabilizing systems must meet extremely high performance requirements, yet allow economical production and assembly. To solve this problem, Barden pioneered special configuration, high precision end-bell bearings.

Pressed into opposite sides of the through-bored rim, these bearings become an integral part of the gyro spin mass while serving as end caps for the gyro wheel assembly. This eliminates delicate fitting of very small bearings into conventional end bells . . . reduces mating-part errors and assembly time . . . improves squareness, concentricity, and overall accuracy and reliability.

One gyro manufacturer reports that the use of Barden Precision end-bell bearings in place of conventional flanged bearings reduced noise levels 50% and made it possible to meet unusually stringent life requirements.

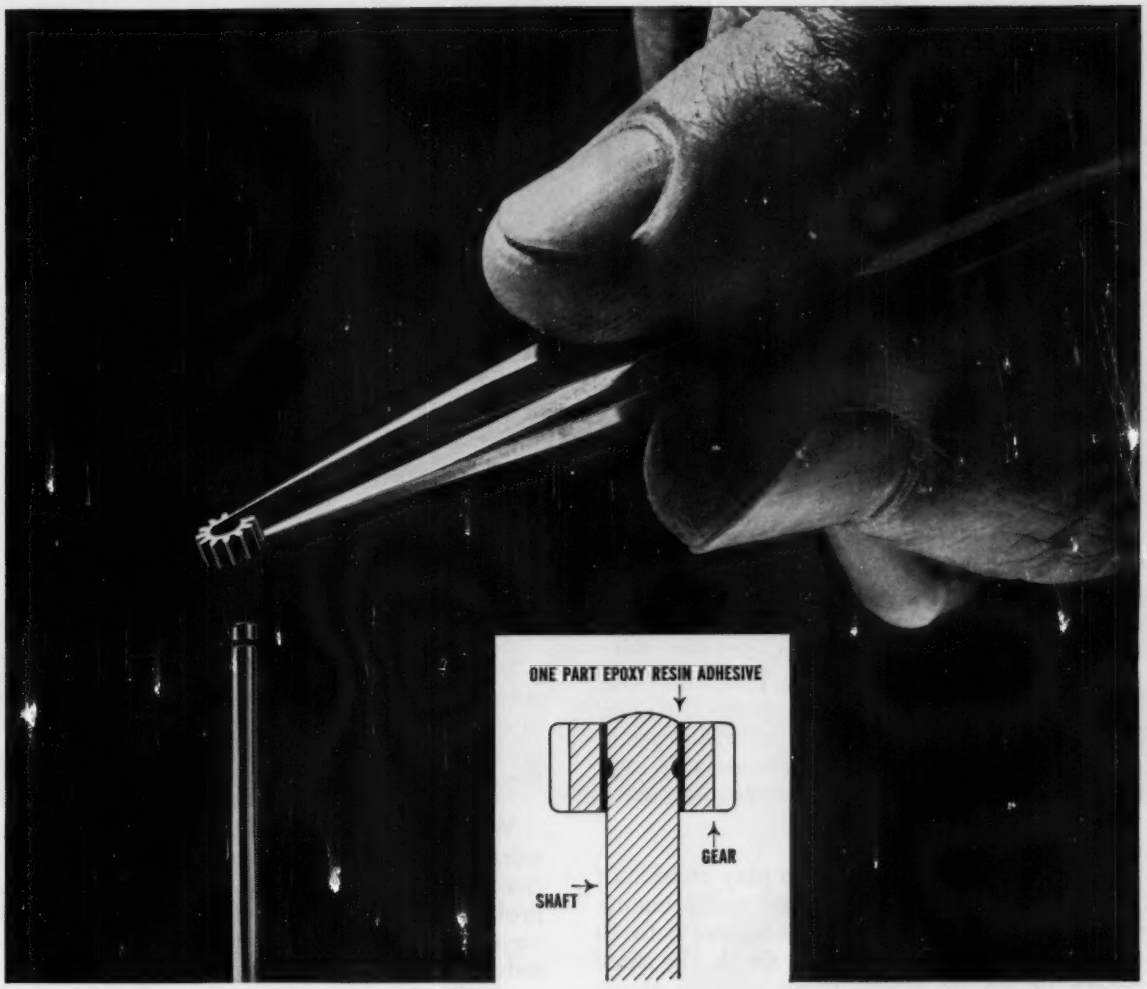
Like other Barden advances in design and production, end-bell bearings solve a specific performance problem. Other Barden Precision bearings satisfy such extreme demands as:

- High temperatures (to 575°F.)
- High speeds (to over 300,000 R.P.M.)
- Low torque (to 10 dyne-cm. for 2 lb. load)
- Concentric rotation (to .00005" max. T.I.R.)

Barden is a major supplier of standard bearings in sizes from .0469" bore to over 3" O.D., all manufactured to Barden Precision standards of dimensional accuracy, uniformity and reliability. See Sweet's Product Design File (8h/Ba) for Barden catalog and bearing selection guide.

for reliability... specify **BARDEN** **PRECISION BALL BEARINGS**

THE BARDEN CORPORATION, 73 Park Avenue, Danbury, Connecticut
Western Office: 3850 Wilshire Boulevard, Los Angeles 5, California



How fabricating with SCOTCH-WELD® BRAND Structural Adhesives eliminated 100% inspection step

Timing components now being fabricated with SCOTCH-WELD Adhesive EC-1386 meet precise specifications. The Haydon Division, General Time Corp., Torrington, Conn., is using this one-part epoxy resin base adhesive to bond small pinion gears to rotor shafts in a sub-assembly timing gear operation.

Prior to use of EC-1386, the parts were joined by brazing. But the high heat required affected the material hardness. It also produced shaft distortion, necessitating a 100% inspection step.

Then SCOTCH-WELD Adhesive EC-1386 was used. The high heat previously required was eliminated. With the end of this trouble source, shaft concentricity and material hardness were left unaffected, the 100% inspection eliminated. Close tolerance requirements between shaft and gear were also eliminated because of void-filling properties of the adhesive. A savings of $56.37 per thousand assemblies resulted.

Company after company is discovering how to save money, speed production and eliminate rejects by using SCOTCH-WELD Structural Adhesives in the fabrication of their products. Perhaps these adhesives are at work right now in operations similar to yours. Find out! For free literature without obligation, write today on your company letterhead to: AC&S Division, 3M Company, Dept. SBR-30, St. Paul 6, Minnesota. "SCOTCH-WELD" is a Reg. T.M. of 3M Co.

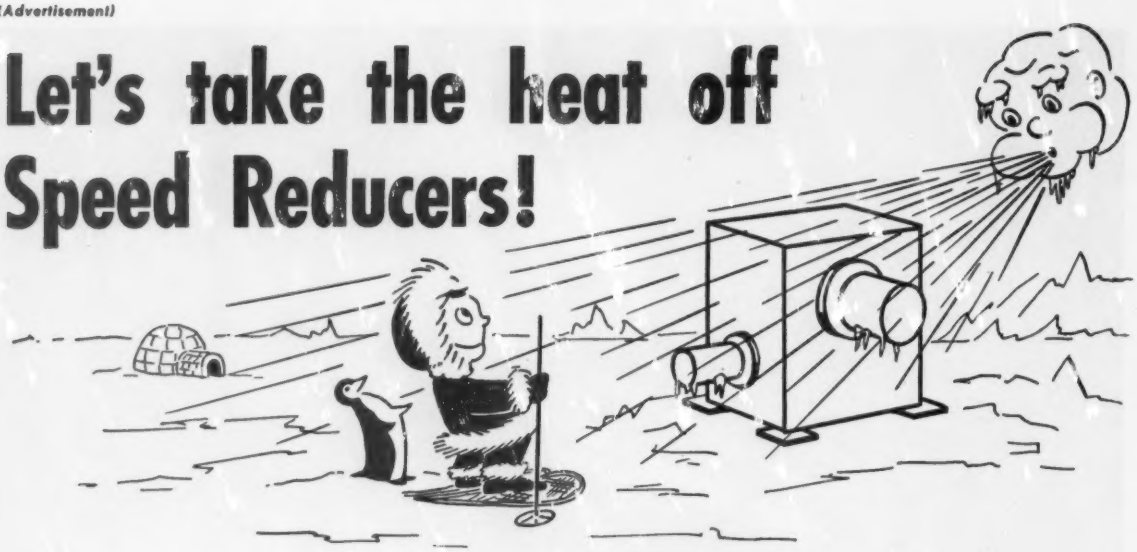
ADHESIVES, COATINGS AND SEALERS DIVISION

MINNESOTA MINING AND MANUFACTURING COMPANY

...WHERE RESEARCH IS THE KEY TO TOMORROW

3M COMPANY

Let's take the heat off Speed Reducers!



A worm gear speed reducer is one of the toughest little customers in captivity. It reduces speeds day-in, day-out, with little complaint. While it works long and hard, it has limitations—set by ratio, center distance, RPM, mechanical and thermal HP ratings, etc. And, depending upon how precisely it was selected and fitted to the job requirements, it will do what it has to do.

But sometimes it's forced to play outside of its league. It must cope with job requirements that vary from here to there—normal 8 to 10 hour service without recurrent shock, the same length of service where there is some shock loading, continuous low-speed service and almost countless others. But the thing that really puts the pressure on reducers, the thing that's lurking in *every* set of job requirements—is h-e-a-t.

When you exceed the thermal capacity of a reducer for more than an hour or so, excessive temperature thins the lubricant resulting in wear; material, bearing and oil seal failures; etc. Of course, the proper lubricant will help but it can't cure the continuing problem of excessive heat.

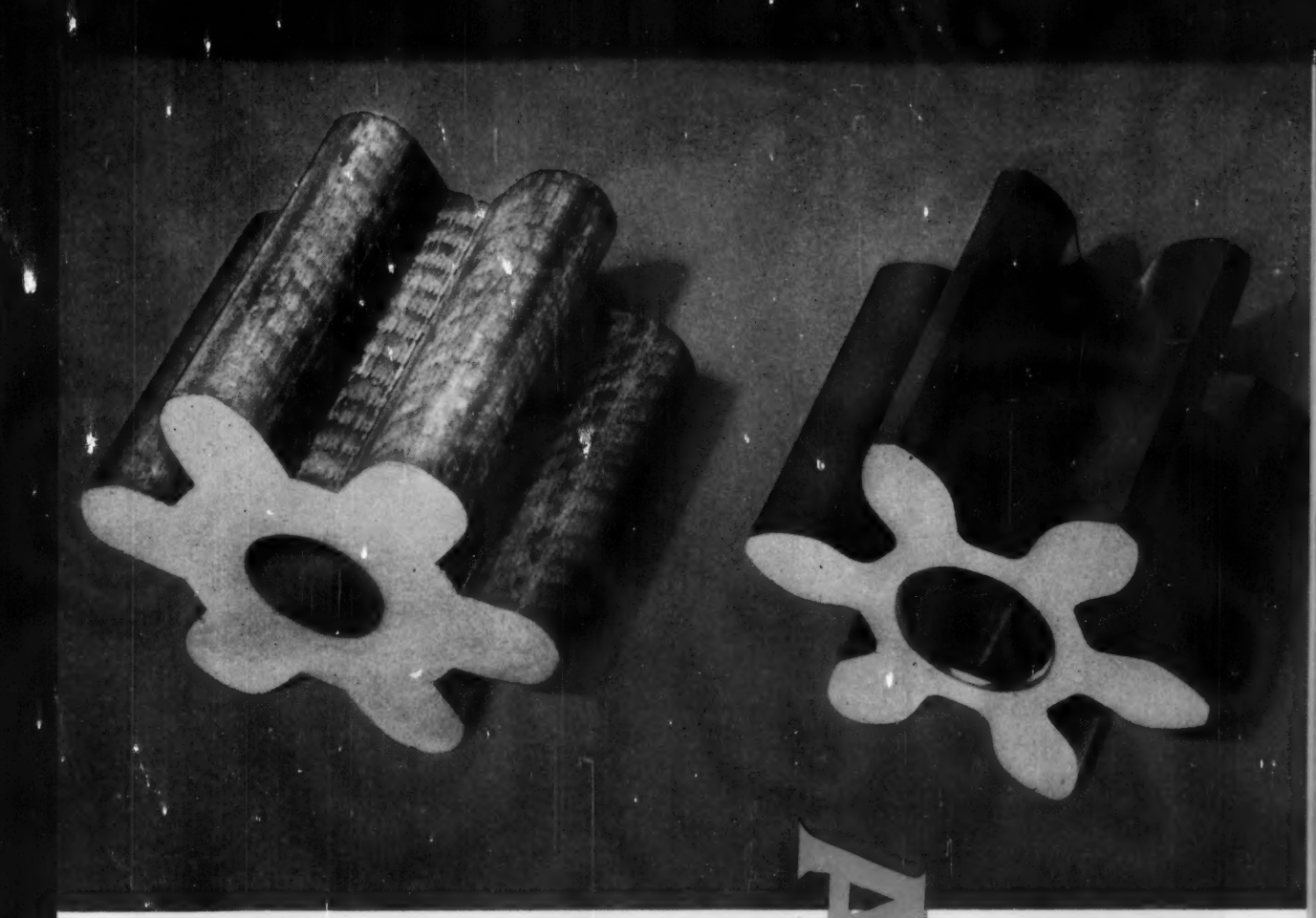
So how can we lick this toughy? One way is to build the reducer housing oversize, big enough to radiate the heat away and keep temperatures down. But this type sticks out in aisles, louses up compact designs and barks shins. Then, we might try a smaller housing complete with fins on it to dissipate the heat. If this still doesn't work, another trick is to use a reducer with capacities and ratings a step above the ones we need. This is sending a man to do a boy's job. It's impractical, inefficient and costly. There *has* to be an easier, better, saner and cheaper way to do it. And there is!

In certain cases, where the size and type of reducer permits and where we can gain enough in thermal HP rating to keep heat generation in bounds, Cone-Drive Gears does it with fan-cooling.

What's that? Simple. Just add a fan to the worm shaft plus the necessary air shields, fan cover, etc., and presto!—heat is no longer a problem. The air shields direct the fan-pushed air over the fins on the lower portion of the reducer. The fins are shaped and spotted to guide the air stream where it is needed. Thermal HP ratings are boosted tremendously, as high as 147% above those of standard reducers in some cases! Those over-worked, over-heated reducers will now do the job you bought them to do.

Other advantages? They're here in abundance. The size of the reducer stays the same. All parts on a Cone-Drive fan-cooled reducer are 100% interchangeable with parts for standard reducers. Oil capacity is identical. Shields are quickly removed without disconnecting the reducer. (This is important where severe operating conditions make periodic cleaning necessary). The reducer can also be operated *without* fan-cooling just by taking off the fan and shields.

This simple addition to standard Cone-Drive HU speed reducers might be just your answer—might save you some money. Write for Cone-Drive's Bulletin CD-218. It will tell you all about the full line of Cone-Drive double-enveloping worm gear reducers as well as the fan-cooled kind. Cone-Drive Gears, Div. Michigan Tool Co., 7171 E. McNichols Rd., Detroit 12, Mich.



Note minimum clean-up necessary between casting of this 6-tooth pump impeller and finished part. (Illustrated parts are 4" in diameter.)

Custom shapes in continuous lengths:

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CONTINUOUS-CAST BRONZE CASTINGS

Before you design or produce a copper base alloy part, investigate the economy and efficiency of Asarco continuous casting. You can order the alloy and shape you need, in the exact lengths you need. Continuous Cast Asarcon Bronze alloys meet SAE, ASTM, and government specifications—but they are superior to the same alloys cast other ways, in hardness, yield, tensile and impact strength. In fact, you may be able to substitute an Asarcon Bronze for an aluminum or manganese bronze. Write for complete data to Continuous-Cast Department, American Smelting and Refining Company, Barber, N. J. or Whiting, Indiana.

Immediately available from stock: **ASARCON 773 BEARING BRONZE** (SAE 660)—260 sizes of rods and tubes. Complete range of sizes from ½" to 9" diameters. Immediately available from stock in 105" lengths. Special shapes produced to order.

ASARCO

AMERICAN SMELTING AND REFINING COMPANY

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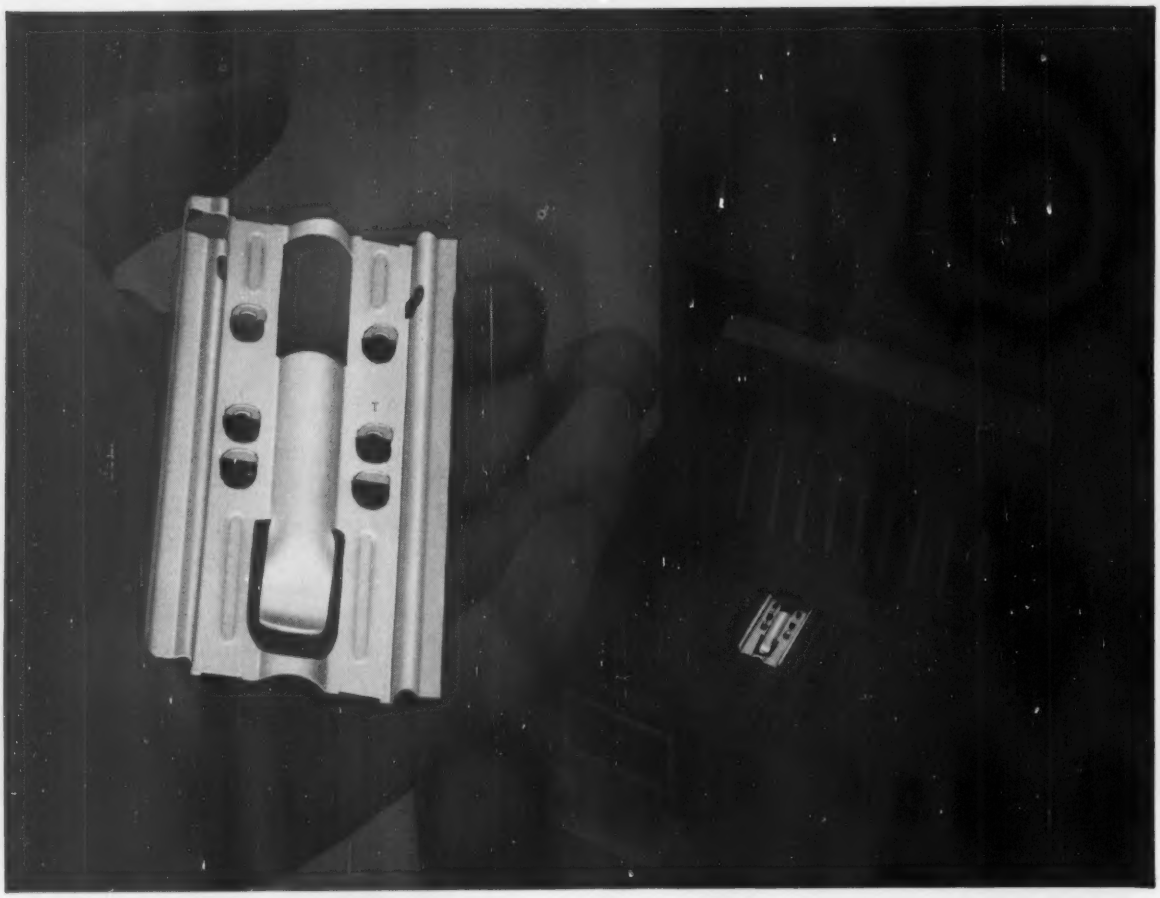
West Coast Distributor: Kingwell Bros., Ltd., 457 Minna Street, San Francisco, Calif. In Canada. Federated Metals Canada, Ltd., Toronto and Montreal. Distributors in many principal cities.

Circle 470 on Page 19



Engineered by Tinnerman...

Easier to assemble...easier to operate... **SPEED CLIP®** costs 50% less, too!

Assembly of the SUPER-FILER® *Divide-a-File* mechanism was considerably simplified when the General Fireproofing Company switched to a special SPEED CLIP design. Sightless people do the assembling without former difficulties of fitting spring wires into non-uniform stampings.

With this SPEED CLIP, the "self-adjusting" *Divide-a-File* slides more smoothly back and forth in the channel. Locking in the desired position is more positive, too.

This is another example of how Tinnerman Engineering goes far beyond the original fastening idea – how we work with customer engineering departments to produce better working units. And in the above case, a per-part cost reduction of 50% was achieved. In only 4 months, General Fireproofing had saved enough through lower assembly and parts costs to write-off new tooling needed to produce the SPEED CLIP.

You, too, can achieve savings and improvements like these on your assemblies. Invite your local Tinnerman sales representative in for a discussion of the SPEED NUT methods of better fastening at lower cost. He's listed in most Yellow Pages, under "Fasteners". Or write to:

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MACHINE DESIGN
March 31, 1960

Upward . . . or Merely Onward?

WHAT shall I tell my nephew? He's a personable 14-year-old with red hair and an interest in math. He likes basketball, and raises tropical fish. He tries to beat me at chess, and sometimes does.

I know he could be an engineer. And he's bound to ask about engineering sooner or later. What should I tell him?

He's idealistic, so maybe he'd like to hear how he might contribute significantly to human progress. *Some* engineers do.

Should I tell him how interesting the work is—how engineers have a chance to create and invent, to see their ideas come to life in metal and plastic? It's often true, but how can I ignore the assignment of competent engineers to subprofessional work?

Employment prospects should be of some interest; engineering talent is supposed to be in demand for many years ahead. But it will bother my conscience if I don't tell him about the mass layoffs common in some branches of our profession.

Should I spell out the executive opportunities — that engineering can be a stepping-stone to bigger and better things in management? And should I also warn him that if he sticks to engineering he'll have difficulty keeping up with his buddies who turn to management or sales?

Regardless of what I tell him, there's a good chance that my nephew will become an engineer. Seven or eight years from now, he'll be coming out of college—looking at his profession with young, eager eyes.

Will he be happy with what he finds? Will the legacy that our profession hands its young be any greater? Will we have moved upward . . . or merely trudged onward?

Robert L. Stedfeld
ASSOCIATE MANAGING EDITOR

An over-all look at

Product Planning

What goes into product planning?

Where does the function fit into the total organization?

How is engineering related to it?

Here's a look at product planning within the framework of the total organization. This view may help engineering better see its obligations and opportunities.

DELMAR W. KARGER and ROBERT G. MURDICK
Dept. of Management Engineering
Rensselaer Polytechnic Institute
Troy, N. Y.

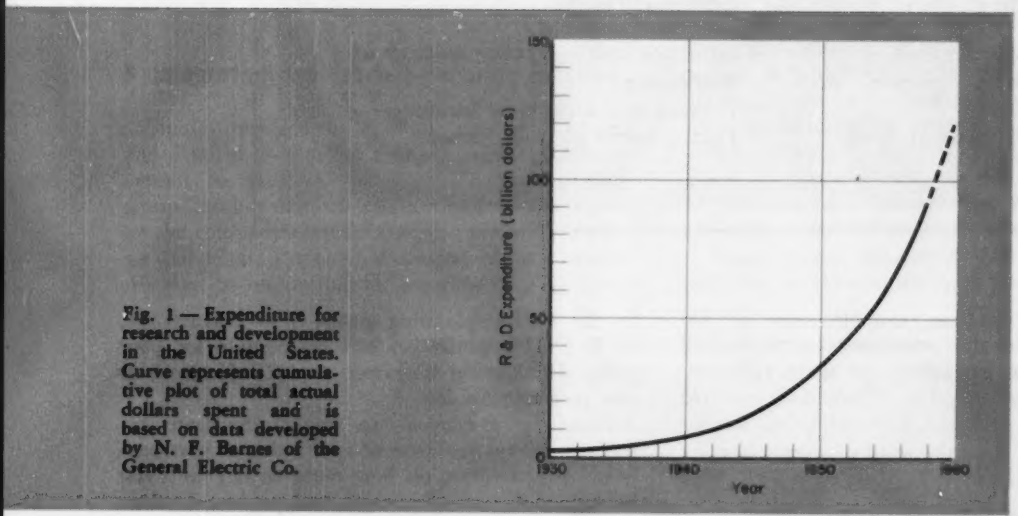


Fig. 1 — Expenditure for research and development in the United States. Curve represents cumulative plot of total actual dollars spent and is based on data developed by N. F. Barnes of the General Electric Co.

A BUSINESS, like any other organism, must either grow or adapt to survive. Business survival depends directly on profitable sales which, in turn, depend on having the right products at the right time. Thus, product planning is at the heart of business strategy. Product planning affects, and is affected by, every activity of the business enterprise. It should be based on a realistic evaluation of over-all company objectives and corporate strengths.

Product planning is often considered to be new-product development, product acquisition, or planning new-product lines. Actually, the concepts should not be limited to the narrow scope of technological advances or acquisitions. In a strategic sense, any form of product differentiation must be a part of product planning. From this viewpoint, therefore, product planning may comprise any, or all of the operations listed in *Methods of Product Differentiation.*

Each of these activities must be oriented to satisfy both the immediate and the future needs of the company. To meet this dual requirement, a basic program which will achieve established company objectives must be formulated. This program needs to be modified continually to suit the ever-changing environment.

Indeed, changes in environment due to technological developments are rapidly accelerating. One measure of the effort which goes into the development of new products, and of the pressure exerted for general technological development, is the expenditure for research and development. An analysis of available data, Fig. 1, shows dramatically the growth of R & D in the United States. Yet, how many companies, even those with R & D budgets, maintain a product-planning function at a high organizational level within the company? Some do not even pretend to establish or implement such plans.

Today, the stakes are large. The winners in the struggle among competitive enterprises will be those who establish a strategy of products subject to modification as conditions change, rather than those who merely rely on situational and/or temporal improvisation. However, while the payoff for general R & D is large, on the average, over a ten-year period, individual projects have a high probability of yielding little or no return. In spite of the poor short-range prospects for individual projects, it is a well-recognized fact that each dollar of R & D

Methods of Product Differentiation

- Add new functional features to present products.
- Improve styling.
- Improve packaging.
- Improve service.
- Expand present product lines.
- Contract number of models for standardization.
- Diversify into new product lines.
- Improve quality.
- Change pricing policy.
- Find new applications for present products.
- Find new markets.
- Introduce new and better methods of distribution.
- Finance and build new facilities.
- Find a better product name.

expenditure will yield an annual return of 100 to 200 per cent on the investment by the end of 25 years. Thus, the expenditure of about $100 million for R & D in 1959, Fig. 1, would be expected to return between $100 and $200 million on this investment by 1984.

Basic Program for Product Planning

In establishing a product-planning program, each company should suit its own peculiarities. However, there are certain basic requirements and steps that are generally applicable. While the scope of the problem presented by each step may vary with the individual company, the basic requirements are universal and will hinder progress until they are resolved. These steps and requirements are outlined in *Basic Program for Product Planning.*

This basic program shows that *product planning consists of mobilization and optimum application of company resources to achieve maximum profits through product leadership.*

The first three steps in this program are the responsibility of the executive officers and the board of directors. While others can gather data, and make tentative evaluations and suggestions, they cannot make final decisions or formulate goals or objectives. Also, if the outlined work is not done, constructive and effective product planning cannot be accomplished. A product-planning group without such guides may waste 50 per cent or more of their own effort, as well as a like amount in participating departments. This waste is a loss few firms can afford.

The accompanying checklists for *Evaluation of Corporate Strength, Determination of Long-Range Goals,* and *Organization of Product-Planning Function* provide an amplification of basic policy questions which should be resolved first. Thorough consideration of every item in these checklists should materially help in producing consistent and effective product planning. No amount of competent effort by the product-planning group, sales organization, or R & D organization can compensate for poor policy decisions on financing, product objectives, or new-product planning.

Focus, for a moment, on one of the more important general problems of application of resources. It involves deciding on how much money to invest in various degrees of research and product-development engineering for product innovation or differentiation. These degrees of business activity, which range from merely staying in business to conducting "blue-sky" research, can be classified into six stages:

1. Barely stay in business by following your competitors. This method of operation is as close to standing still as possible, and is extremely dangerous to the life of the firm.
2. Improve the product, continally to keep abreast of competition. This approach will not result in growth of the company. It is the bare minimum that a firm can do with any real assurance of being able to stay in business.
3. Round out the product line and improve the products to lead the field at least some of the time. This level of activity is really the least that a progressive company can do.
4. Diversify but maintain technical continuity based on company experience and talent.
5. Diversify and merge with, or acquire, other companies in fields with no thread of technical continuity.
6. Conduct pure exploratory or "blue-sky" research of an undefined nature.

Maintenance of technical continuity, stage 4, is often the key to success. Rather than spend money for "blue-sky" research, most companies would be well advised to concentrate their efforts on stage 4, and use stage 5 for entering new fields. Few firms have the resources, financial and other, to take advantage of "blue-sky" research developments. Finally, companies with no prior R & D experience should not forget that the R & D expenditure is only a small portion of the costs associated with launching new products. For example, one corporation had to increase their long-term debt from $2 million to over $100 million in a ten-year effort before returns

from a new-product, requiring an extensive R & D effort, exceeded the outgo.

To find the answer to the problem of allocating resources, details of the basic product-planning program must be developed in terms of the entire business system, including its environment. A lengthy discussion of this detailed program is beyond the scope of this article, although most of the basic aspects have been covered here in outline form, except one—organization.

▶ Integrating the Product-Planning Function

Studies required to develop the grand strategy and detailed program of product planning obviously cannot be the work of any individual or single group in other than the smallest business. Depending on the company's organization for product planning, an individual, a functional component, or a committee may be responsible for insuring that all aspects of the basic program are carried out continuously, and in a timely fashion. But, whatever the circumstances, an integrated approach to product planning is essential if business objectives are to be optimized.

Organization for product planning, as outlined in the checklist previously mentioned, deserves special attention in the effort to take an over-all system approach. Product planning should be conducted by a high-level staff group. Since all business functions are involved, decisions based upon staff planning and alternatives must ultimately be made by the person or group responsible for profit or loss, success or failure, of the business. With the complexity and specialization in business today, the decision-maker, whether president, executive committee, or board of directors, will probably seek the counsel of the functional managers, as well as their concurrence, in major product-planning decisions.

Where should the product-planning individual or staff be fitted into the organization? Here again,

Basic Program for Product Planning

1. Determine and evaluate corporate strengths and weaknesses in all areas. This step includes, but is not restricted to, the following:
   a. Corporate board.
   b. Executive talent.
   c. Quantity and quality of general and professional manpower, including special strengths in pertinent areas such as scientific, engineering, skilled crafts, common labor, etc.
   d. Financial position and capabilities.
   e. Facilities.
   f. Markets and marketing positions.
   g. Corporate image and reputation.
2. Determine long-range over-all business goals, and long-range financial, technical, production, and marketing objectives. These should be related to anticipated company capabilities and future environment.
3. Organize the product-planning function and establish specific and detailed policies and plans on the basis of steps 1 and 2.
4. Develop and/or find new-product ideas suited to company capabilities, market needs, and desired profit margins.
5. Determine market and approximate financial potentials of promising ideas.
6. Select the best new-product ideas and develop them into new products meeting specified requirements in accordance with the over-all plan. This plan must take into account time schedules and priority of new product developments.
7. Conduct manufacturing, marketing, and product-service activities required to introduce new products successfully.
8. Establish measures and standards for evaluation of results; measure the success of each of the preceding activities; and improve the product planning and development program in terms of these measurements.

Check list for
Evaluation of Corporate Strength

1. Corporate Board
   a. Makeup. Are the board members young or old? Are they aggressive and willing to take chances? Or are they conservative and try to avoid all risks?
   b. Attitudes. How do the board members feel about mergers and acquisitions?
   c. Perspective. Is the board dominated by an individual or a group, or by any set of biases or prejudices which may affect new product planning?
   d. Experience. Is the executive experience of the board broad enough to guide development and marketing of new-product lines or entry of the company into a completely new field?
2. Financial Position
   a. Capital structure.
   b. Retained income, credit, and availability of capital.
   c. Contingent liabilities.
   d. Flexibility of fiscal policies.
3. Manpower
   a. Managerial personnel. What are their qualifications on the basis of age, present ability, special talents, and potential growth?
   b. Depth of management talent or back-up for present managers.
   c. Engineering and scientific talent. What is the company engineering strength in terms of number and quality of engineers by field, depth in field, and specialties?
   d. Professional talent other than engineers and scientists. What quality, quantity, and variety of talents, such as financial specialists, salesmen, marketing specialists, production and industrial engineers, etc., are available?
   e. Technical supporting personnel (laboratory assistants, computer programmers, engineering assistants).
   f. Skilled, semiskilled, and unskilled labor. What quality and quantity are available within the company, and what potential reserves are there in surrounding areas? What is the labor history in the area, and the union limitations?
   g. Geographical dispersion of plants and employees.
   h. Compensation practices.
   i. Morale and loyalty of employees.
4. Facilities
   a. Number, size, location, type, layout, condition, and modernness of manufacturing plants, warehouses, and offices.
   b. Types, kinds, condition, modernness, and adaptability of manufacturing equipment.
   c. Accessibility to transportation, raw materials, and markets.
   d. Operating and maintenance costs.
   e. Ownership, or leasing arrangements.
   f. Excess capacities by classifications.
   g. Availability of adequate amounts of water, power, and other required utilities.
5. Market Considerations
   a. Total market for present product lines.
   b. Fraction of total market for each product manufactured.
   c. Reasons for not having a larger share of the market.
   d. Market structure. What are the customer characteristics, the geographic locations of markets, price-volume relationships, product substitutes, and life of present products in the market.
   e. Replacement parts market.
   f. Seasonal and other important cyclical factors.
   g. Competitive position by product, and in total.
   h. Channels of distribution (types, number, and strength).
   i. Service policies, facilities, organization.
   j. Market research ability.
   k. Brand recognition.
   l. Type and cost of advertising and sales promotion.
   m. Service policy.
   n. Price and discount structure.
   o. Patent position.
6. Scope of Corporate Charter

Check list for
Determination of Long-Range Goals

1. Business prospects and directions for the next ten years.
   a. Projected technological, economic, and market trends.
   b. Horizontal and vertical diversification of product lines.
   c. Expansion of present product lines.
   d. Entry into new related and unrelated fields.
   e. Entry into frontier fields (atomic energy, space flight, solar energy).
2. Financial condition and structure of business in view of projected product plans.
3. Technical objectives as related to manpower, organization, facilities, and financial strength.
4. Plants, locations, facilities, and manpower required for products in relation to raw materials and markets. Also, what production and control policies will be required to insure steady output and maximum utilization of facilities?
5. Marketing objectives.
   a. Type of markets.
   b. Size and shares of markets.
   c. Advertising.
   d. Methods of distribution.
   e. Service and replacement parts.

Check list for
Organization of Product-Planning Function

1. Formal organization.
   a. Objectives, scope, responsibilities, and structure of product-planning operation.
   b. Accountability and authority of individuals charged with product-planning functions.
   c. Reporting and relationship responsibilities of personnel.
2. New product-planning policies.
   a. Improvement, expansion of lines, diversification of products.
   b. Technical development work (internal or subcontract).
   c. Acquisition of new companies, or mergers.
   d. Technical policies. To what extent is the company willing to invest in technical leadership?
   e. Manufacturing policies. To what extent is the company willing to invest in substantial or specialized manufacturing facilities? What are the prevailing attitudes on inventory policies, vender relationships, and stable or intermittent production policies?
   f. Facilities policies. What are company attitudes on questions of geographical location; buy or lease; build or buy; buy now or over a period of time; and buy for planned expansion?
3. Over-all Timing
   a. Schedule for timing of organization development and changes.
   b. Schedule for planning and implementation of all new product policies to insure orderly and synchronized operation.

the answer depends on the emphasis given various parts of the basic program. The main concept to remember is that product planning and all new-product activities cut across and involve all major functional areas. Hence, they must be highly placed activities which are so assigned that the required movement is facilitated.

Sometimes, product planning may be a part of the marketing function. Such is often the case in companies with highly competitive product lines. On the other hand, in companies selling mainly R & D services, the product planning function may be in the R & D division. However, there are some serious drawbacks in not having the product-planning activity report directly to top management. It should reflect top-management thinking and cut across almost every company function. When it is assigned to a subfunction, product planners tend to reflect the viewpoint of the function, and may have trouble in obtaining positive assistance and co-operation from other functions.

The nature and duties of the individual or group to whom the responsibility for product planning is delegated, as well as the function's status, its scope of activity, and its relations with other functional groups of the company, will be determined largely by three factors: 1. Organizational placement of the function. 2. Internal and external characteristics of the company. 3. Abilities of the individuals concerned.

One example of an excellent type of organization-reporting relationship that is used by one company is the combination of product planning and operations research in a business-operations group reporting directly to the general manager, Fig. 2. Both product planning and operations research are concerned with high-level system studies. Both activities require men with broad business background, including some with high analytical ability, and others with creativeness, imagination, and daring. Both activities are vitally concerned with survival of the business at present, and in the future.

Since planning is the main responsibiilty of every functional head (engineering, manufacturing, marketing, etc.), the framework of operation of the product-planning group must be so set up that it does not usurp the duties and responsibilities of these other functions. Rather, it should draw on their strengths and utilize them in the most effective manner. One sure way to eliminate danger of usurpation is to limit the size of the product-planning group.

In addition, the charter of the product-planning group should indicate that the group's responsibility is the encouragement, stimulation, and co-ordination of the other functions' planning in regard to product development. Product planners must work with these other functions to provide guidance, inspiration, unity, compatibility, and the top-management viewpoint. A vital part of their job is to assemble the results of these co-ordinated efforts and to formulate alternative plans for decisions by top management. Product planners working on a full-time basis maintain the continuity of the product-planning activity.

In such a complicated process as product planning, responsibilities cut across functional lines of authority. Many steps must be performed with precise timing and many people must participate in each step. So, some device must be used to co-ordinate these efforts. In this operation, the product-planning group must be strong. An excellent way to simplify and to co-ordinate such a complex effort is to prepare a checklist of each step to be accomplished, including the organizational component and the individual responsible for each step.

Since the grand strategy of business is to make the optimum profit on a product, it is particularly essential that the product-planning activity is recognized as woven into every phase of the business and is organized accordingly. This over-all system approach to the product-planning function is the key to success.

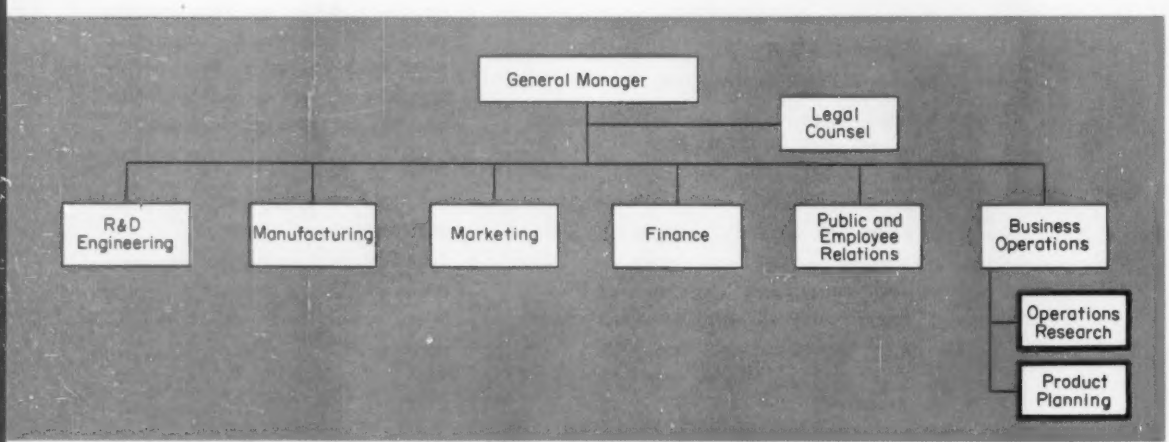
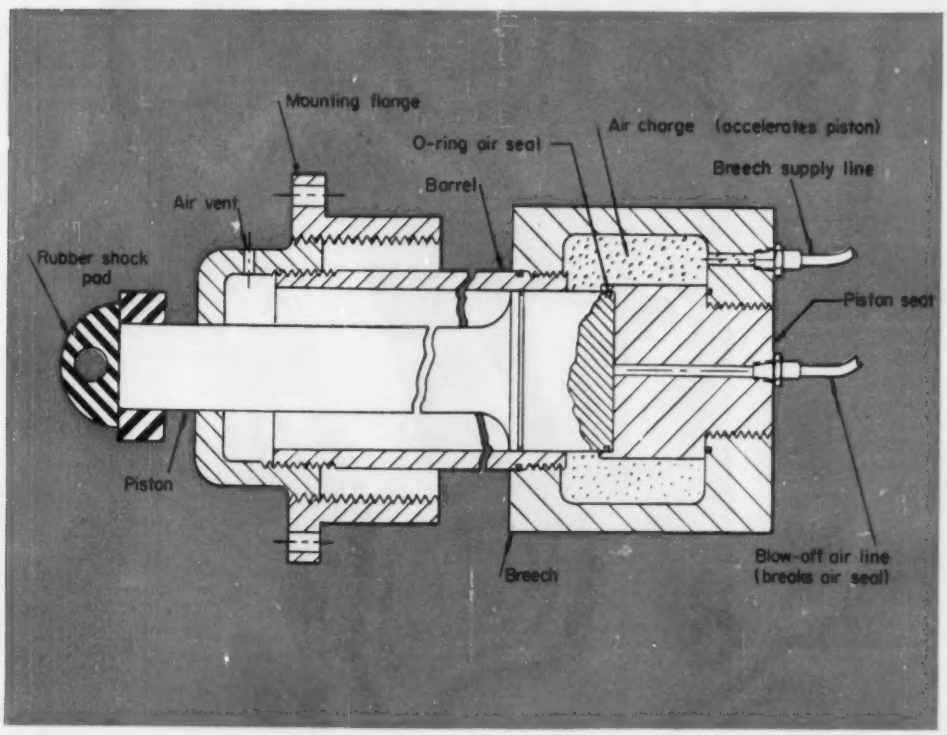


Fig. 2—Organization chart showing reporting relationships when product-planning and operations-research functions are combined in the business-operations group.

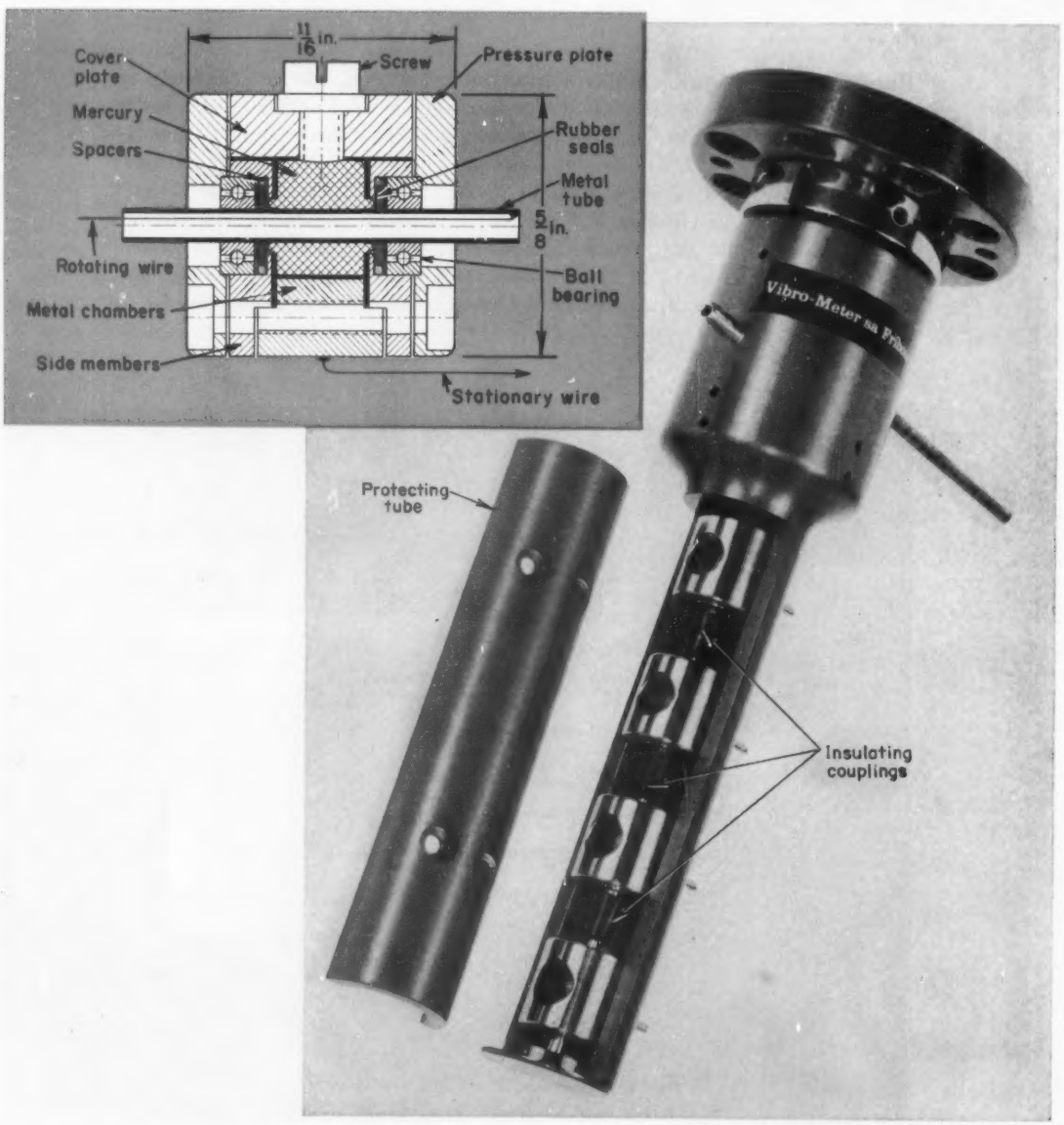
scanning the field for *ideas*

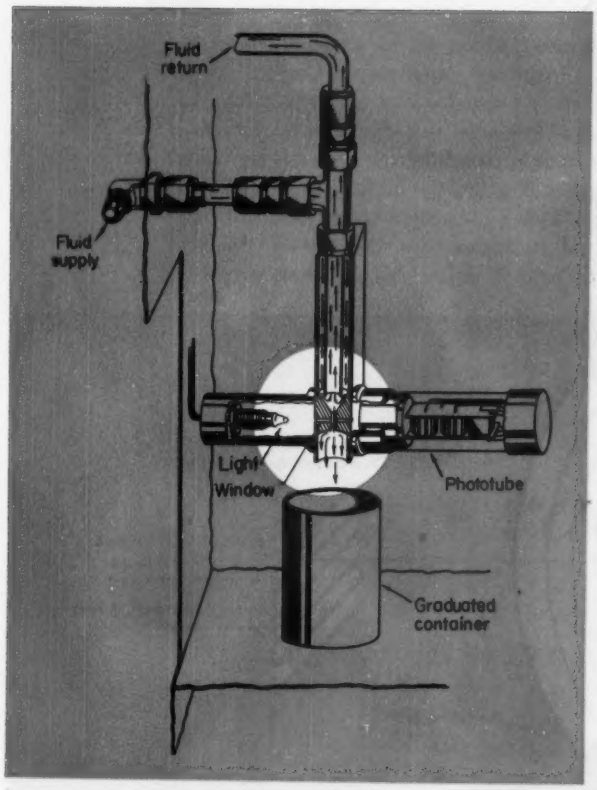
Pneumatic trigger permits acceleration cylinder to operate completely on compressed air. The acceleration device is simply a combination quick-opening valve and air cylinder in which an air charge is built up in the annular chamber around the piston head. The driving force on the piston is governed by the pressure of the accelerating air charge. In operation, the desired pressure is built up in the air-charge chamber and the unit is fired by introducing low-pressure air behind the piston, unseating it. The piston moves forward striking and accelerating a test vehicle. Reported by G. Stathopoulos, trigger employed in an acceleration test rig developed by U. S. Naval Ordnance Lab, Silver Spring, Md.



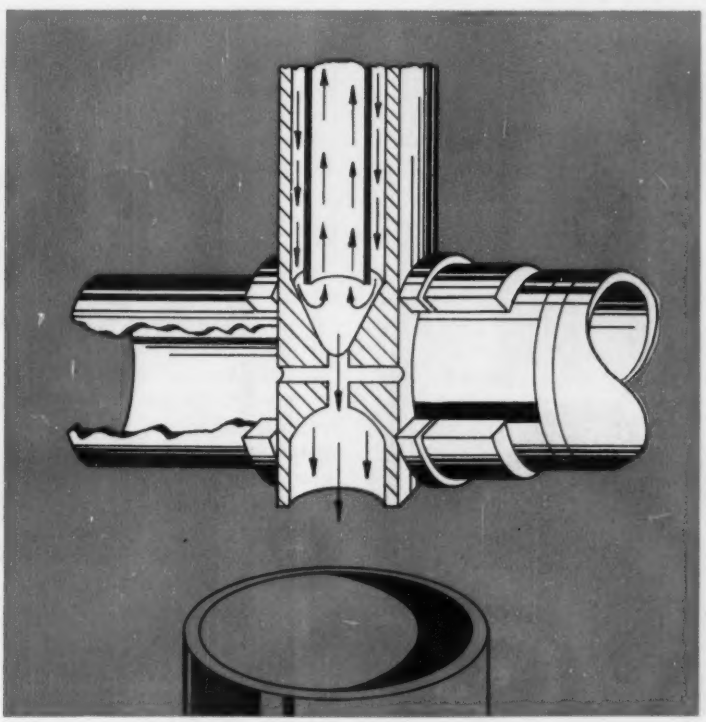
SCANNING THE FIELD FOR IDEAS

Platinum-iridium plating stabilizes contact resistance between rotating and stationary components to minimize undesirable thermovoltages in rotary pickup. Instead of slip rings and brushes, mercury transmits currents from rotating thermocouples or strain gages to stationary measuring devices. A metal tube, made of platinum-iridium, is surrounded by mercury which takes up the entire space between tube and metal chamber components. The chamber consists of annular "side" members and cover plate, all platinum-iridium plated on the surfaces contacting the mercury. Rubber seals prevent mercury from escaping between metal tube and side members. Developed by Dr. Ing Christof Rohrback, transmission principle employed in rotary pickup by Vibro-Meter AG, Fribourg, Switzerland.



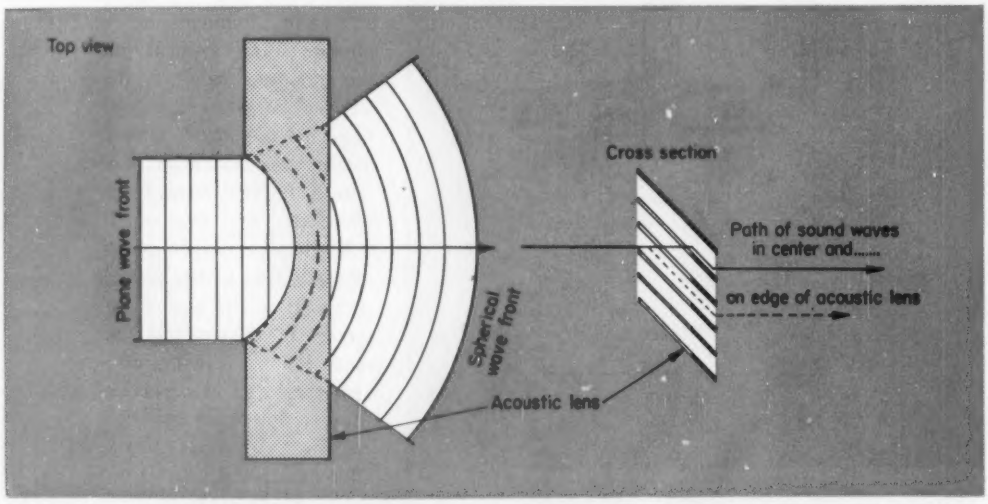


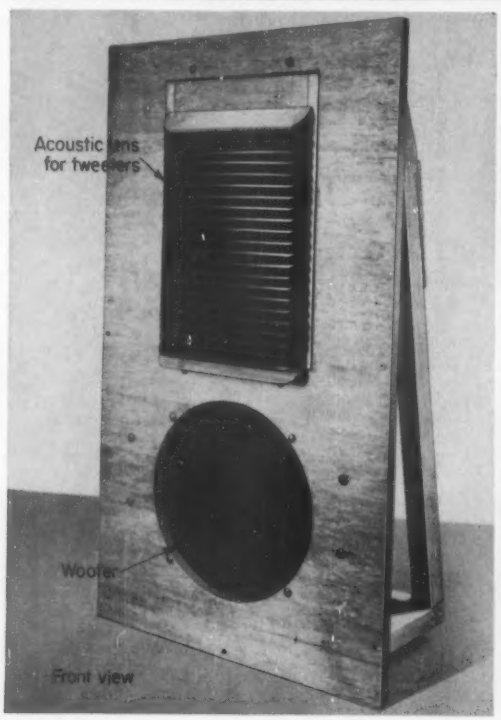
Viewing window in tube wall permits fluid contamination to be measured electronically. The fluid is pumped past a window in a stream so small that the foreign particles of a certain minimum size pass the window one-by-one. A light beam, directed through the window and the fluid stream, impinges on a photosensitive element on the opposite side of the stream. As a foreign particle in the fluid stream passes the window, a portion of the light beam is interrupted. The photosensitive element produces an output signal which is proportional to the size of the particle interrupting the light beam. Viewing window employed in a particle counter developed by High Accuracy Products Corp., Claremont, Calif.

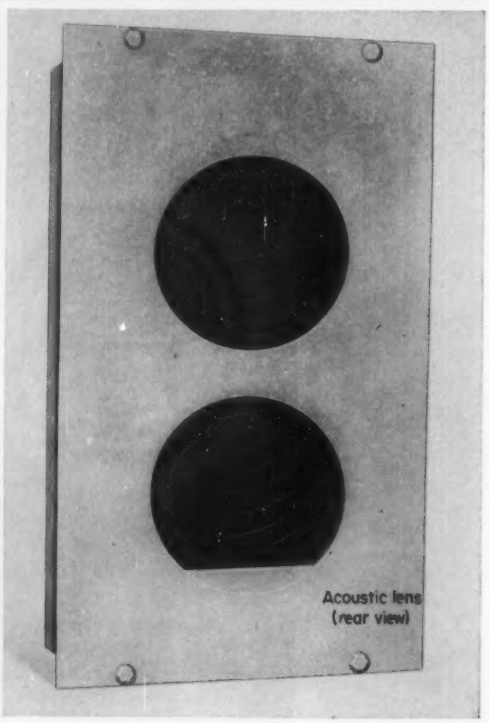


SCANNING THE FIELD FOR IDEAS

Semicircular cutouts make loudspeaker screen act as acoustic lens to increase horizontal dispersion angle of high-frequency sound waves. Cutouts are on rear side of screen only, facing the tweeters. As sound waves are deflected by inclined screen lamellas, the deflection path is longer on the edge than in the center of the screen. As a result, a plane wave front approaching the screen is converted into a spherical wave front and dispersion is primarily in horizontal direction. Vertical dispersion is kept to a minimum. This arrangement counteracts unidirectional sound radiation normally observed in high-frequency tweeters. Acoustic lens used in loudspeaker developed by Siemens & Halske AG, Munich, Germany.







Engineers are often entrusted with confidential information. Its improper disclosure raises not only an ethical issue but sometimes a legal one as well. Liability may be involved, depending on how the courts answer the question:

What is a Trade Secret?

ALBERT WOODRUFF GRAY
Forest Hills, N. Y.

LACK of clear definition is probably nowhere more apparent in the law than in the efforts of the courts to describe the legal features of trade secrets. Court suits involving issues with almost identical features may result in different decisions depending on the court's interpretation of the qualities necessary to a trade secret.

The American Law Institute has summarized the characteristics of a trade secret: "A trade secret may consist of any formula, pattern, device or compilation of information which is used in one's business, and which gives him an opportunity to obtain an advantage over competitors who do not know or use it. It may be a formula for a chemical compound, a process of manufacturing, treating or preserving materials, a pattern for a machine or other device, or a list of customers. It differs from other secret information in business in that it is not simply information as to single or ephemeral events in the conduct of the business . . . .

"A trade secret is a process or device for continuous use in the operation of a business. Generally it relates to the production of goods as, for example, a machine or formula for the production of an article.

"The subject matter of a trade secret must be secret. Matters of public knowledge or of general knowledge in an industry cannot be appropriated by one as secret. Matters which are completely disclosed by the goods which one markets cannot be his secret.

"Substantially a trade secret is known only in the particular business in which it is used. It is not requisite that only the proprietor of the business know it. He may, without losing his protection, communicate it to employees involved in its use. He may likewise communicate it to others pledged to secrecy.

"Others may also know of it independently as, for example, when they have discovered the process or formula by independent invention and are keeping it secret. Nevertheless a substantial element of secrecy must exist so that except by use of improper means, there would be difficulty in acquiring the information.

"An exact definition of a trade secret is not pos-

sible. Some factors to be considered in determining whether given information is one's trade secret, are: (1) the extent to which the information is known outside the business; (2) the extent to which it is known by employees and others involved in his business; (3) the extent of measures taken by him to guard the secrecy of the information; (4) the value of the information to him and to his competitors; (5) the amount of effort or money expended by him in developing the information; (6) the ease or difficulty with which the information could be properly acquired or duplicated by others."[1]

AN Indiana manufacturer of miniature silicon rectifiers filed complaint in the U. S. District Court of California against eight former employees and another manufacturer. The complaint charged that the former employees had knowledge of secret production know-how and other information which the Indiana corporation had acquired by large expenditure and used in its business.

The complaint also charged that the second manufacturer had conspired with the former employees by hiring them for the purpose of depriving the first manufacturer of trade secrets and resulting advantage over other competitors.

Among its defenses, the rival manufacturer contended that the art of manufacturing silicon rectifiers was not a trade secret and that such rectifiers had been manufactured by more than two dozen companies throughout the United States for almost every known electronic device and were generally well known in industry from descriptions in books, periodicals, patents, government reports, and other sources.

Concluding that no trade secrets were involved here, the court said, "The law does not require the employee to make a tabula rasa of his mind by erasing from it the knowledge he has acquired.

"Employees who had conducted a special department entered into the employ of another in an open field. The former employer had no patent on the art nor had he discovered any process which was not known or readily discernible by others in the field. This manufacturer was entitled to claim his own trade secrets but not the general secrets of the trade in which he is engaged."

This statement was supplemented with the comment, "What is a trade secret, is difficult to define. However, on the whole, it must consist of a particular form of construction of a device, a formula, method or process that is of a character which does not occur to persons in the trade with knowledge of the state of the art or which cannot be evolved by those skilled in the art from theoretical description of the process or compilation or compendia of information or knowledge.

Liability for Disclosure of Trade Secrets

One who discloses or uses another's trade secret, without a privilege to do so, is liable to the other if

(a) he discovered the secret by improper means, or

(b) his disclosure or use constitutes a breach of confidence reposed in him by the other in disclosing the secret to him, or

(c) he learned the secret from a third person with notice of the facts that it was a secret and that the third person discovered it by improper means or that the third person's disclosure of it was otherwise a breach of his duty to the other, or

(d) he learned the secret with notice of the facts that it was a secret and that its disclosure was made to him by mistake.

—From *Restatement of the Law of Torts*, American Law Institute Publishers, St. Paul, Minn., 1939, Chapter 36, Section 757.

"Injunction is not available to an employer to restrain a former employee if the alleged secrets are not in truth secrets. Matters of public knowledge or of general knowledge in an industry cannot be appropriated by one as his secret."[2]

THE same feature which led to the collapse of the previous court action was also involved in a suit in New Jersey. Here it had been alleged that secret methods and processes for photographically marking precision dials had been disclosed by former employees, and as a consequence these secrets were being used by competitors.

Although the lower court had refused to enjoin the competitor from a further use of this process, the appellate court took a contrary view. In holding that the process was a trade secret and entitled to protection, the court said: "There is no absolute way of determining whether something is or is not a trade secret. Some factors to be considered are the extent to which the information is known outside of the business, the extent to which it is known by employees and others involved in the business, the extent of measures taken to guard the secrecy of the information, the value of the information to the owner and its competitors, the amount of effort and money expended in developing the information and the ease or difficulty with which the information could properly be acquired or duplicated by others.

"A trade secret may consist of a plan, process, formula, device or compilation of information used in one's business and which affords an opportunity to obtain an advantage over competitors who did not know or use it. There must be employed creative faculties in originating it amounting to a meritorious discovery.

"The trade secret need not, however, be patentable. It may be a device or process which is clearly anticipated in the prior art or one which is merely a mechanical improvement that a good mechanic can make. Novelty and invention are not requisite for a trade secret as they are for patentability.

"In our view the subject matter of the process was such as to constitute a trade secret. It required long and extensive research to perfect the machine, the several process operations and the materials which are essential to the method. There is the instance of the paint. Over $15,000 and many months were spent in research to discover a paint which would meet certain defense contract specifications. It turned out that the answer to the problem was a proprietary product but the use made of it was otherwise unknown to the industry.

"These admitted and uncontradicted facts impress us and lead to the conclusion that the process is of a character which in appropriate cases should be protected by our courts as a trade secret. The fact is that none of its competitors could achieve the high degree of accuracy and fine technical finish on dials and panels that it did, even after they had gone through the plant.

"The fact that individual process steps are known to industry and the further fact that every product used by this manufacturer can be bought in the open market does not weaken the conclusion we reach."[3]

Comparison of the preceding cases indicates something of an answer to the judicial comment, "What is a trade secret, is difficult to define." In the California case, evidence indicated that the electronic parts were being manufactured by more than two dozen companies throughout the U. S. In the New Jersey case, somewhat different circumstances were involved. Evidence showed that above the entrance to the manufacturer's plant was a sign, "We are working under a secret process." Visitors were required to pledge themselves to make no disclosures of their observation of this work, and the process was not described in detail even to the court.

Secrecy, then, is an essential feature. Lacking that no protection can be claimed.

A PRIOR New Jersey case also involved the disclosure of information claimed by its owner as entitled to protection as a trade secret. Denying a recovery, the court said, "It is elementary that before one can be charged with unlawful violation of a confidence acquired while in the employ of another, it must be first established that there was in fact a trade secret, owned and used by the employer.

"A trade secret within the rules pertaining to the rights which can be protected by injunction, is a plan, process, tool, mechanism or compound, known only to its owner and those of his employees to whom it must be confided in order to apply it to the uses intended. The inference from the testimony before us is that this product is capable of duplication or imitation by persons familiar with the trade. In order to prevail a substantial element of secrecy must exist so that except by use of improper means third parties would have difficulty in acquiring the information needful."

As to alternatives, the court added, "On the other hand trade secrets are not given protection against all the world or persons who have not learned the secret by improper means or by virtue of a fiduciary relationship. All that the owner of a trade secret is entitled to is protection from a breach of contract or confidence against one to whom he has confided the secret and those to whom such person may divulge it and anyone who honestly and fairly comes into possession of the secret, has the right to use, discuss or sell it without being subject to restraint by injunction."[4]

REFERENCES

1. *Restatement of Law of Torts.* American Law Institute Publishers, St. Paul, Minn., 1939, Chapter 36, Section 757.
2. Sarkes Tarzian Inc. v. Audio Devices, 166 *F.S.* 250, Calif., Sept. 8, 1958.
3. Sun Dial Corp. v. Rideout, 102 *Atl.* 2d 90, N. J., Jan. 6, 1954.
4. Boost Co. v. Faunce, 86 *Atl.* 2d 283, N. J., Feb. 6, 1952.

Hydrodynamic Drives 1

Fluid Couplings

- *Fluid-flow paths*
- *Performance at various loads*
- *Reverse rotation of turbine*
- *Overspeeding of turbine*

Hydrodynamic drives—fluid couplings and torque converters—have features in common: Both provide "slip" between prime mover and load. Both damp out mechanical shock. The torque converter additionally offers torque multiplication. Also, both drives can be designed to offer other unique operating features for particular applications.

When do you use a hydrodynamic drive? Whether fluid coupling or torque converter, how do you specify the right one?

This article is the first of a comprehensive series designed to help answer these questions. The series will provide a thorough working knowledge of hydrodynamic drives, with particular emphasis on the torque converter.

Basic operating principles will be presented first. Then, the detailed characteristics that must be considered in selecting a hydrodynamic drive will be discussed: Application to prime movers . . . engine-converter performance curves . . . extreme speed ratios . . . direct-drive, split-torque, and retarding arrangements . . . cooling systems . . . limiting devices.

W. B. GIBSON
Hydraulic Division
Twin Disc Clutch Co.
Rockford, Ill.

STRUCTURALLY, the fluid coupling consists of an impeller with radial vanes, or blades, and a similar matching turbine. Fig. 1 shows a typical sectional outline, with recommended terminology, taken from the SAE Handbook. Fluid is contained in the hollow toroidal chamber enclosing the impeller and the turbine. As the impeller rotates, the fluid carried by the blades is under the influence of various forces. These forces give the particle the components of velocity as shown in Fig. 2.

Component U represents velocity of a fluid particle at point A on the impeller blade. The velocity is due to rotation of the blade about the axis of the impeller. Component U is always tangent to the path of rotation in the direction of rotation. Component F represents fluid velocity in the axial plane. Component F is always tangent to the design path and perpendicular to component U. Effective velocity V of the particle of fluid is the resultant velocity of components U and F.

The velocity components for a particle of fluid having moved to point B are essentially the same—component U is in the plane of rotation, tangent to the path of rotation in the direction of rotation; and component F is tangent to the design path in

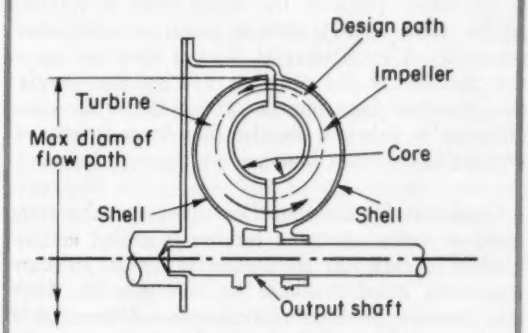
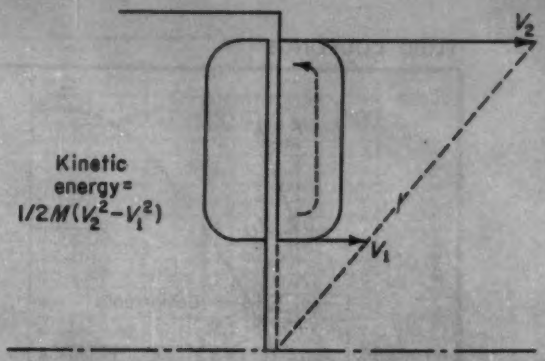


Fig. 1—Fluid coupling nomenclature.



Kinetic energy diagram. The energy absorbed by the fluid depends upon its mass and increase in velocity.

Essentials of Hydrodynamic Drives

ALL hydrodynamic drives fall into either of two categories—fluid couplings or hydraulic torque converters. In both, power from the prime mover is absorbed in a centrifugal pump or impeller. Fluid is accelerated from a relatively low velocity near the center to a high velocity at the outer diameter. Therefore, the power absorption characteristics of both types follow the basic laws for centrifugal pumps.

The following relationships are basic to the selection and use of hydrodynamic drives:

Power capacity is proportional to (impeller speed)^3

Power capacity is proportional to (impeller outside diameter)^5

Torque capacity is proportional to (impeller speed)^2

Torque capacity is proportional to (impeller outside diameter)^5

The fluid coupling is the basic hydrodynamic drive. Work done by the prime mover in accelerating fluid from low to high velocity is turned into kinetic energy—that is, energy inherent in the speed acquired. This kinetic energy of the fluid is given up to a turbine in which the fluid loses speed while being guided back toward the center of the chamber. There it re-enters the impeller in a continuous process. The torque transmitted by the unit is determined by the amount of fluid being transferred from impeller to turbine, as well as by the change in fluid speed. The drive is effected by the absorption of energy as the fluid gathers speed on the outward flow in the impeller, and the release of energy as the fluid loses speed during the inward flow in the corresponding driven member. The vectorial representation of this hydrodynamic principle above applies to both fluid couplings and torque converters.

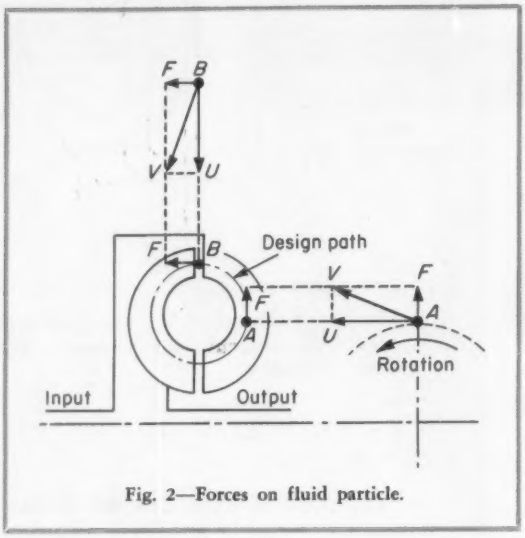


Fig. 2—Forces on fluid particle.

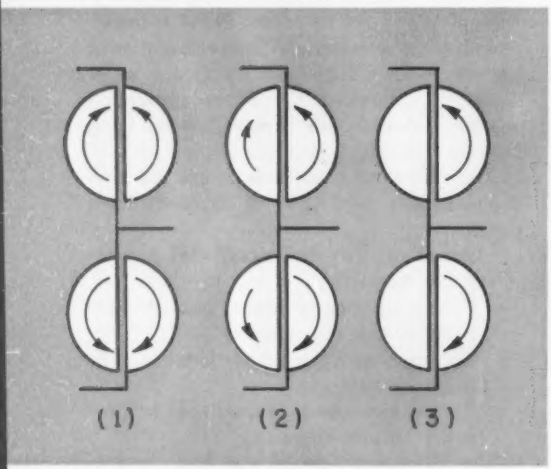


Fig. 3—Fluid-head conditions.

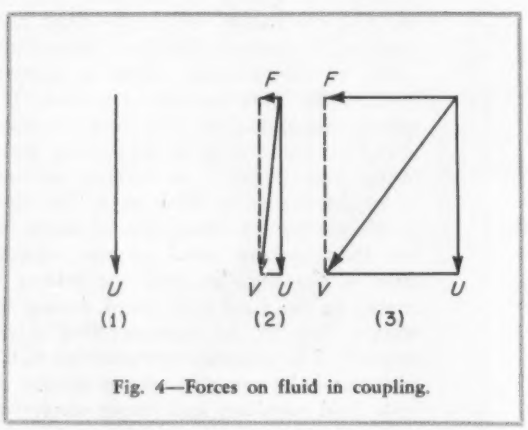


Fig. 4—Forces on fluid in coupling.

the direction of flow. These relationships are true for a given load condition regardless of where the particle of fluid is along the design path.

Operating Conditions

Fig. 3 and 4 indicate the following conditions: 1. No slip (no load)—impeller and turbine rotating at the same speed. 2. Moderate slip (normal load)—impeller rotating at same speed as in 1, turbine lagging slightly. 3. Maximum or 100 per cent slip (stall load)—impeller rotating as before, turbine stalled.

Condition 1: If the impeller and turbine rotate at the same speed, the turbine sets up a head of fluid equal and opposite to the head of fluid set up by the impeller. Since the heads balance, there is no movement of fluid between the impeller and the turbine. Therefore, there is no transfer of kinetic energy from driving to driven member, and no power is available at the output shaft. Velocity vector V then coincides with rotational component U, and axial component F is zero. The path described by any particle of fluid will be one of pure rotation about the axis of the unit.

When there is no slip, there is no transfer of energy from the impeller to the turbine. Therefore, no power is available at the output shaft, and no power is absorbed from the engine.

Condition 2: When there is moderate slip (normal load), the turbine lags behind the impeller, producing a differential head between the fluid in the impeller and in the turbine. Furthermore, the differential head increases with an increased difference in speed. This head produces the movement of fluid from impeller to turbine at the outer diameter. Velocity V is the resultant of component U as before (because the input shaft is rotating at the same speed), and a moderate axial component F. A circulation of fluid is then set up in the chamber of the coupling. During this circulation, the flow from impeller to turbine at the outer diameter is balanced by the flow from turbine to impeller at the inner diameter.

Condition 3: The impeller rotates at the same speed as before, but the turbine is stalled and no head is generated by the stationary turbine to counteract the head produced by the impeller. Since this situation produces the maximum differential in head, the volume of fluid transferred from impeller to turbine is also a maximum, and the axial component of velocity is as large as possible. Hence, effective velocity V has a maximum value, indicating the highest possible rate of fluid circulation and the maximum transfer of kinetic energy from impeller to turbine.

A summary of the foregoing conditions shows that the torque capacity of a fluid coupling is zero when operating without slip. As load is applied to the output shaft, the slip increases. When constant input speed is assumed, the torque absorbed

and transmitted increases until the maximum torque capacity is attained at 100 per cent slip (turbine stalled).

Normal Coupling Function

Fig. 5 shows the torque capacity characteristics for an actual fluid coupling suitable for matching to an engine developing 100 net hp at 1800 rpm governed speed. This hypothetical engine is used throughout later discussions for a common reference. The torque absorption curve, Fig. 5, is for a 14.5-in. fluid coupling operating at a constant input speed of 1700 rpm.

Point *A* represents Condition 1. With no slip, torque transmitted is zero and torque absorbed is theoretically zero. However, a slight torque is absorbed to overcome turbine bearing friction. Therefore, efficiency is zero at this point.

Point *B* represents Condition 2. The full net torque of 292 lb-ft is absorbed at the 1800-rpm engine (input) speed. Fig. 5 shows the torque capacity for a constant input speed of 1700 rpm. The torque required at 1700 rpm based on the capacity-speed relationship defined in *Essentials of Hydrodynamic Drives*, is

$$292 \times \left(\frac{1700}{1800}\right)^2 = 260 \text{ lb-ft}$$

The corresponding speed ratio is 0.96, and the efficiency is 96 per cent.

Point *C* represents Condition 3. At stall load, 1488 lb-ft torque is absorbed at 1700 rpm input speed. Since the torque demand curve is for a constant speed of 1700 rpm, the torque required at 1800 rpm is

$$1488 \left(\frac{1800}{1700}\right)^2 = 1668 \text{ lb-ft}$$

At 1800 rpm with 1668 lb-ft, the power requirement is 572 hp—an impossible situation for a 100-hp engine.

As the load on the output shaft increases, the turbine slows down, producing a greater speed differential between the impeller and the turbine. The increased torque absorbed by the coupling places a greater torque demand on the engine. Hence, the engine speed is reduced until the coupling torque demand is in balance with the torque available from the engine. Since the engine has a relatively flat torque curve and the torque absorption capacity of the fluid coupling is proportional to the square of the input speed, a balance is rapidly reached. Fig. 6 repeats the three conditions previously discussed. Additionally, it illustrates the "square law" for torque absorbed by the fluid coupling, the relatively flat engine torque-curve, and the "balance" obtained at 800 rpm input speed and stall load.

In general, the torque capacity of a coupling in a given set of conditions depends upon the mean diameter of the fluid chamber and the rate of fluid transfer from driving to driven members. Rate of fluid transfer is influenced by design of the fluid chamber, shape and section of the passages, and resistance of the passages to circulation.

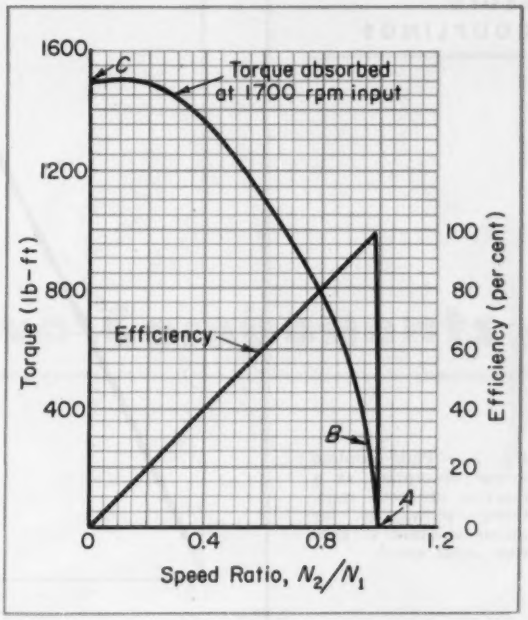


Fig. 5—Torque absorption and efficiency of a fluid coupling as functions of speed ratio.

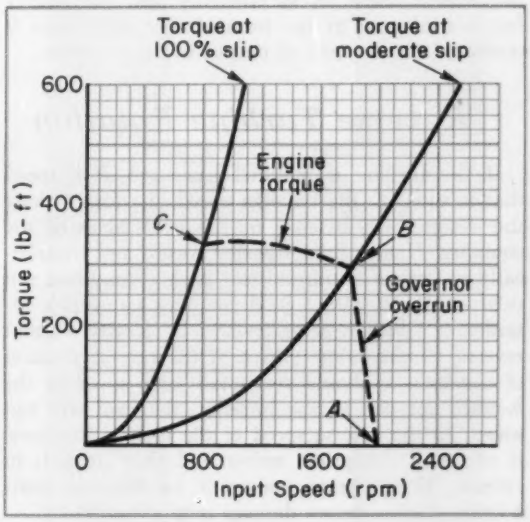


Fig. 6—Fluid-coupling torque as a function of input speed and slip.

Torque capacity of a coupling varies from zero to a maximum according to the slip at which it is operating. However, industrial couplings are usually designed to match the prime mover at 3 to 4 per cent slip for normal load. Input torque and output torque are always equal, because the kinetic energy absorbed in the impeller is equal to that released in the turbine. Furthermore, acceleration and deceleration of the fluid in the two members are equal since the process is continuous. Therefore, the slip

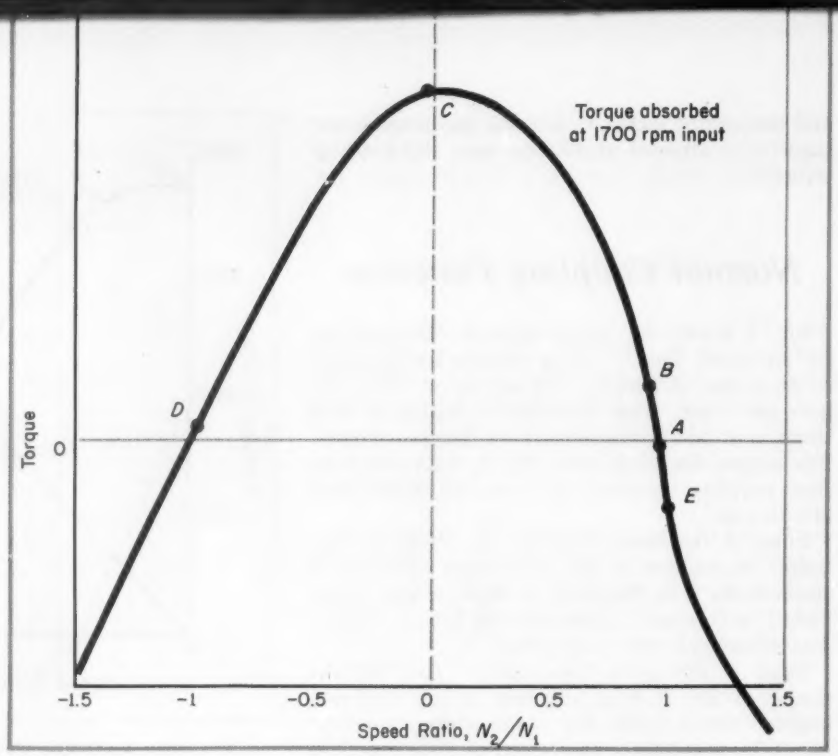


Fig. 7 — Fluid-coupling torque absorption as a function of speed ratio. Curve shown is for torque absorbed at 1700 rpm input speed.

indicates a reduction in efficiency and the energy lost is dissipated in the form of heat. Efficiency is measured as the ratio of output to input speeds.

Reverse Turbine Rotation

If the turbine is motored backward at a speed that is equal to the impeller speed, the forces along the design path balance in the two halves of the coupling. Hence, fluid transfer ceases, and theoretically no torque is transmitted. Such a condition can exist in a hoist with a fluid coupling acting as a retarder, if a load is being lowered by gravity without reversal of the prime mover. If the reverse rotation of the turbine should reach the same speed as the forward rotation of the impeller, the load will run away. As the reverse speed of the turbine increases, it can stall the prime mover and then drive it in reverse. If the prime mover is an internal combustion engine, severe damage might result.

In one application, it was impossible to lower loads quickly enough by gravity because of the retarding action of the coupling, until—paradoxically—the engine speed was increased. Throttling the engine down to lower the load reduced the impeller speed and the impeller fluid-head below the capacity required to hold the load stationary. As the load fell, increasing the speed of the turbine in the negative direction, the turbine fluid-head exceeded the impeller head and fluid flow was reversed. At this point a retarding action was established, which prevented the load from falling as rapidly as desired. When the throttle was adjusted to prevent engine stall, the load could be lowered at a satisfactory speed. Actually, the impeller and turbine speeds were matched, as were the impeller and turbine fluid-heads. This action established a minimum retarding effect.

In practice, the two coupling halves, rotating at equal and opposite speeds, produce sufficient turbulence to absorb about one-quarter of the normal full load engine torque. The energy of this retarding effect is dissipated as heat.

Overrunning Turbine Speed

If the turbine speed exceeds the impeller speed in the same direction of rotation, the turbine head overcomes the impeller head and the fluid flow is reversed. Under this condition, the impeller tends to overspeed in the positive direction and act as a retarder. If a constant impeller speed is assumed, torque capacity at a speed-ratio of 1.04 equals torque capacity at a speed-ratio of 0.96, as shown by point *E*, Fig. 7.

For example, a skip hoist is powered by an 1800 rpm normal starting torque induction motor. A load, which could be hoisted at 4 per cent slip within the coupling, would travel at

$$(1800 \text{ rpm} - 50 \text{ rpm motor slip}) \times$$
$$0.96 \text{ coupling speed ratio} = 1680 \text{ rpm}$$

This same load could be lowered at

$$(1800 \text{ rpm} + 50 \text{ rpm motor slip}) \times$$
$$1.04 \text{ coupling speed ratio} = 1924 \text{ rpm}$$

The motor would then be functioning as a generator and both the motor and the coupling would be retarding the load.

The next article in this co-ordinated program will discuss the fundamental principles and the characteristics of torque converters.

Here's an assortment of answers to the question: Which method to use in

Mounting Servo Components

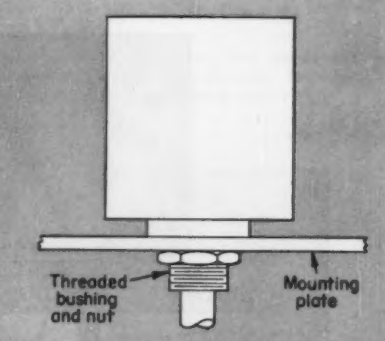
FRANK WILLIAM WOOD JR.
Engineer
Systems Development Dept.
Vitro Laboratories
Silver Spring, Md.

SELECTION of the mounting method for servocomponents depends on requirements for accuracy and simplicity of installation, ease and accessibility for maintenance, number and nature of parts, adjustability, and over-all cost. Here are representative methods and notes on their particular features. Motors, instead of other kinds of servo components, are used here simply for purpose of illustration.

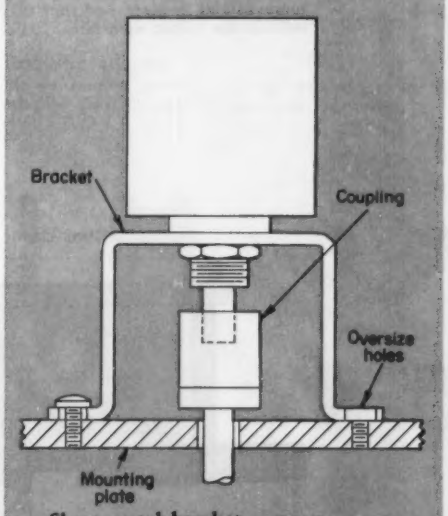
To determine suitability of methods in actual cases, ask these questions:

- Must the component housing have grooves for clamps?
- Must the component housing have tapped holes to receive screws for mounting?
- Is a bushing mount provided? If so, what is the tolerance on concentricity of bushing and component shaft?
- Will zeroing at final assembly require rotating component housing?
- If a gear is mounted to a component shaft, should component mounting be adjustable to minimize gear backlash?
- Will removal of component for replacement involve a major disassembly of the entire servo unit?

In many mounting methods, clamps are essential hardware. Ideally, clamps should: 1. Consist of a minimum number of parts. 2. Require only standard tools for installation and removal. 3. Provide positive clamping action that will not release under shock and vibration. 4. Permit component removal without fully removing clamps or clamps hardware.

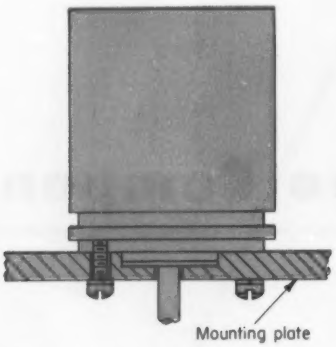


Threaded bushing
makes adapters and clamps unnecessary. Bushing is useful where motor mount is absent. However, the motor cannot be phased easily.

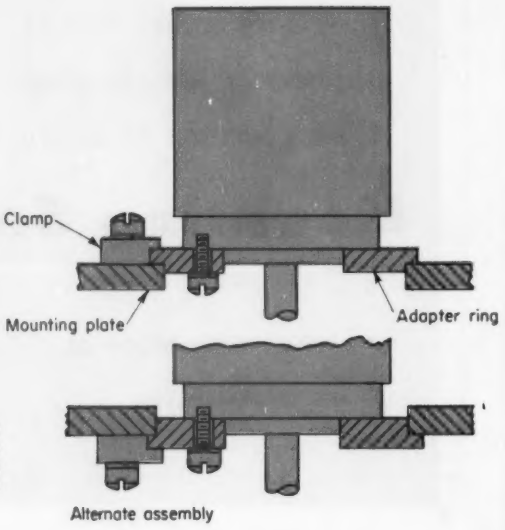


Sheet metal bracket
is inexpensive to make, and substitutes for a conventional motor mount. Wide sheet-metal tolerances make extra care necessary in alignment during final assembly. To aid in alignment, oversize screw holes enable lateral shifting.

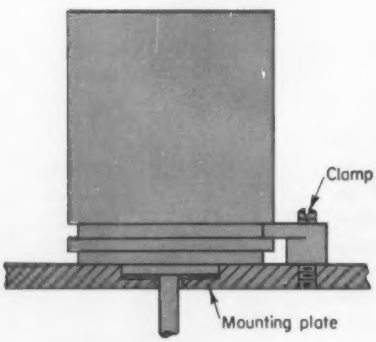
MOUNTING SERVO COMPONENTS



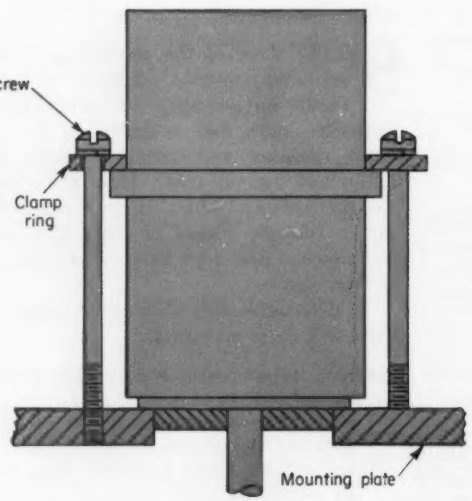
Tapped holes
in motor itself confine fastening means within the motor OD. Mounting plate has only through holes—none tapped. However, motor cannot be rotated for phasing and cannot readily be removed in tight quarters.



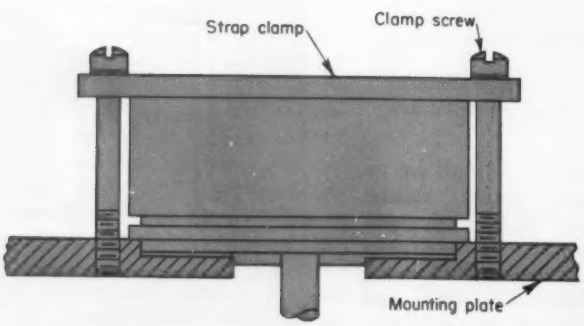
Adapter ring
held by clamps facilitates phasing and removal of motor. Ring adds to over-all cost.



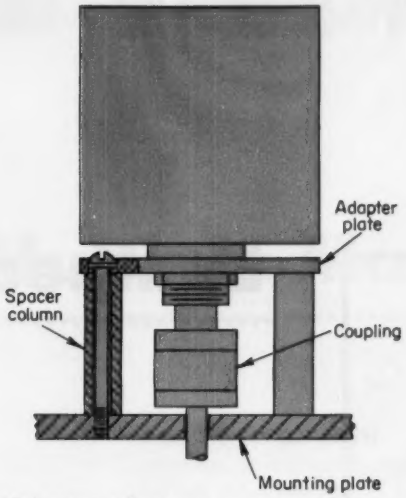
Clamps
enable motor to be rotated for phasing, and facilitate removal of motor. However, they are additional parts to handle, they require tapped holes in plate, and they occupy space outside the motor diameter.



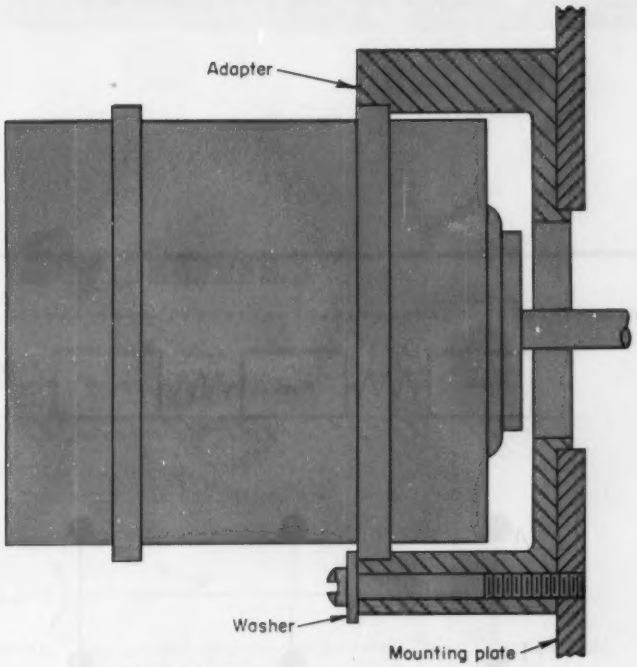
Clamp ring
enables motor to be rotated for phasing, and is inexpensive. Clamp ring requires a shoulder on the motor and it projects outside the motor OD.



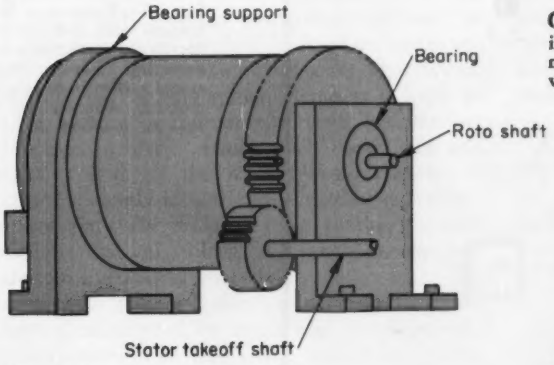
Strap clamp
is inexpensive to make, and allows phasing of motor. But this clamp occupies space outside motor OD.



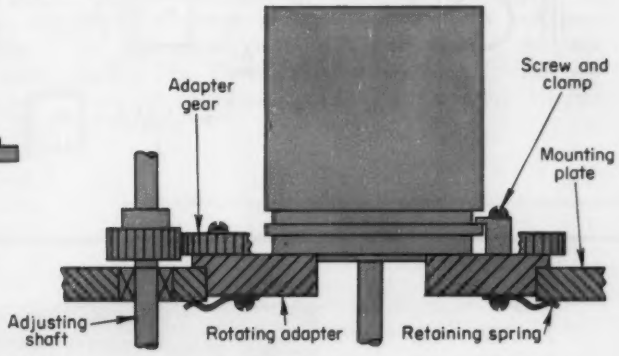
Columnar adapters
confine assembly within motor OD, and enable axial adjustment of over-all assembly length. Coupling facilitates engagement with next larger assembly. Characteristic length of assembly may be a disadvantage.



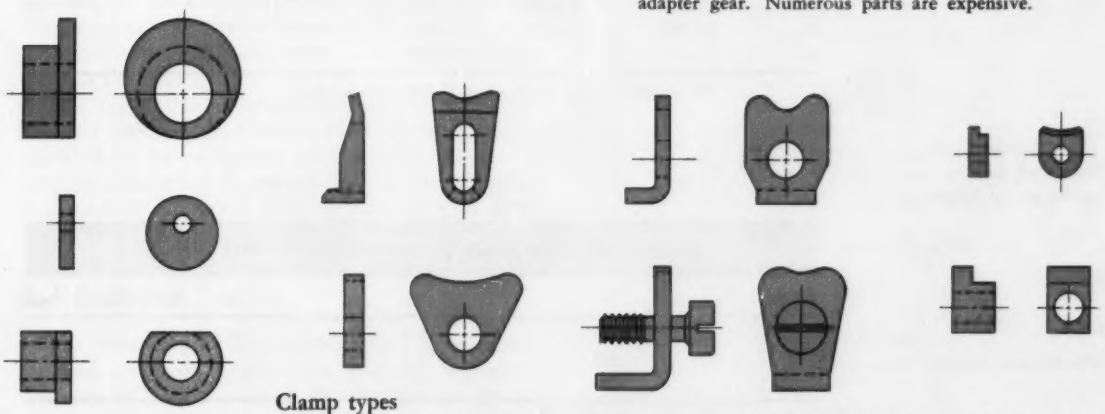
Cylindrical adapter
is counterbored to seat motor, and enables retraction of motor without disturbing adjacent assembly. Disadvantage is extensive machining required.



Rotating stator
is provided by mounting end of stator in bearing support and rotor shaft in antifriction bearing. Stator takeoff is through gear pair which could be braked to allow rotation of rotor only.



Rotating adapter
allows remote phasing through adjusting shaft and adapter gear. Numerous parts are expensive.



Clamp types
include eccentrics which engage or disengage motor in one-half turn. Flattened side of concentric type does the same job. Elongated-hole type need not be removed to free a motor. Captive-screw type prevents separation of fastenings—an advantage in tight spots.

Lumped

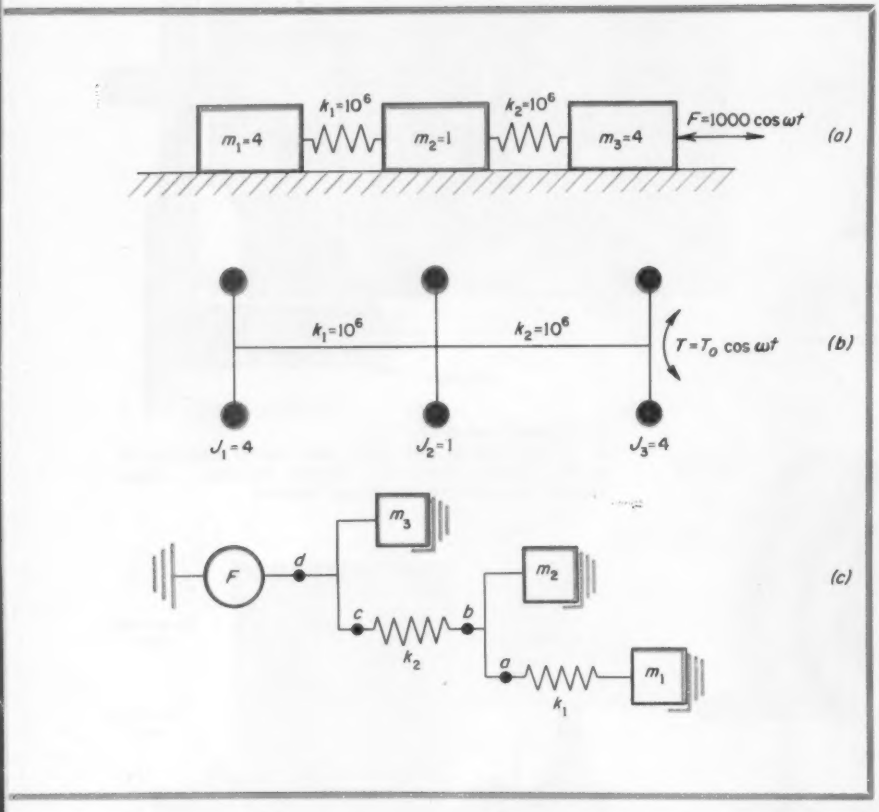


Fig. 17—Three-mass elastic systems with end excitation. Rectilinear system in *a* is dynamically similar to torsional system in *b*. Schematic mobility diagram for both systems is shown at *c*.

Table 6—Holzer Table for Analyzing Impressed-Frequency Relationships of Three-Mass System*

m	$m\omega^2$	R_o	$m\omega^2R_o$	$\Sigma m\omega^2R_o$	k	ΔR_o
4	472,000	0.00188	882	822	10^6	0.00088
1	118,000	0.00100	118	1000	10^6	0.001
4	472,000	0	0	1000		

*Based on systems in Fig. 17 when $\omega = 344$ rad per sec.

Table 7—Normal Mode Shapes for Three-Mass System*

Mode	ω	x_{1o}	x_{2o}	x_{3o}
O	0	+1	+1	+1
I	500	+1	0	−1
II	1500	+1	−8	+1

*Based on systems in Fig. 17.

Multiple-Mass Systems

AUSTIN H. CHURCH
Chairman, Mechanical Engineering Dept.
College of Engineering
New York University
New York, N. Y.

DETERMINATION of the response of a vibrating system becomes increasingly difficult as the number of degrees of freedom increases. In systems with more than two degrees of freedom, behavior of the various system elements is hard to visualize because of the complex force and motion relationships involved. Under such conditions, advantages offered by the mobility and impedance concepts[1] of analysis are more readily apparent. They not only aid understanding of the physical interactions that take place, but they also simplify and shorten the work of analysis.

Use of three general methods of vibration analysis has been demonstrated for single and two-degree-of-freedom systems.[2,3] In this article, attention will be focused on methods of handling systems with many degrees of freedom.

For a system with many degrees of freedom, solution by the classical method requires the use of either determinants or a trial method involving Holzer tables. The component-mobility method also becomes cumbersome, but the schematic diagrams are helpful in setting up the response equations. However, the normal-mode mobility method is a practical approach, particularly if a response spectrum is desired.

The application of component and normal-mode mobility methods to multiple-mass systems is illustrated here for a system having three degrees of freedom. Excitation is applied first to the end mass, and later to the center mass. A solution is obtained for both conditions.

End Excitation

The procedure for determining the response spectrum of a system having more than two degrees of freedom will be illustrated for the systems shown in Fig. 17*a* and *b*. Note that excitation is applied at an end mass in both cases. To facilitate plotting of response curves, numerical values are assigned to the various system components. Response will be found first by the component-mobility method and then by the normal-mode mobility method.

Component-Mobility Method: The systems in Fig. 17*a* and *b* are dynamically similar and may be represented by the schematic mobility diagram in Fig. 17*c*. Principles for constructing this diagram have already been covered.[1] Point *a* in Fig. 17*c* has

Nomenclature

F	= Force, lb
J	= Mass moment of inertia, in.-lb-sec^2
k	= Spring gradient or rate, lb per in.
M	= Mobility
M_V	= Velocity mobility, in. per lb-sec
m	= Mass, lb-sec^2 per in.
R	= Response
T	= Torque or moment, lb-in.
t	= Time, sec
v	= Velocity, in. per sec
x	= Linear displacement, in.
Z	= Impedance
Z_V	= Velocity impedance, lb-sec per in.
β	= Ratio of impressed to natural frequency
ω	= Circular or angular frequency, rad per sec
Subscripts	
a, b, c, d	= Point locations in a system
i	= Effective
k	= Spring element
m	= Mass
n	= Natural or resonant
o	= Amplitude or vector length; characteristic
s	= Spring
O, I, II	= Mode numbers

[1]References are tabulated at end of article.

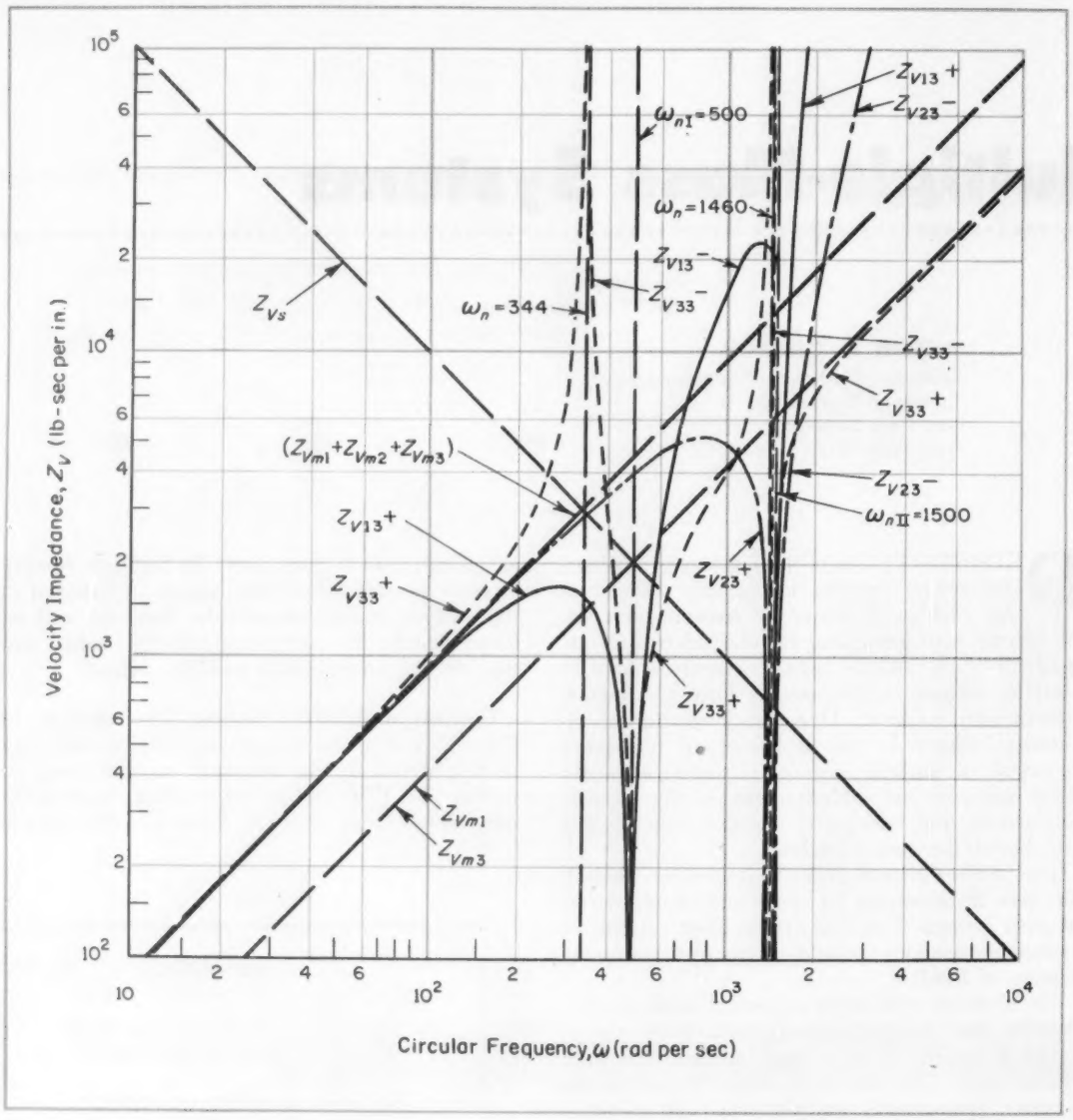


Fig. 18—Velocity-impedance response spectrum for the three-mass system with end excitation shown in Fig. 17*c*.

the same motion as point *b*, and point c has the same motion as point *d*. Then, from Equations 18 and 21,[1]

$$M_a = M_{m1} + M_{s1} \quad (55)$$

$$Z_b = Z_a + Z_{m2} \quad (56)$$

$$M_c = M_b + M_{s2} \quad (57)$$

$$Z_d = Z_c + Z_{m3} \quad (58)$$

Impedance at *d* represents the response function at mass m_3, resulting from a force applied at that point, and, therefore, is the driving-point impedance, Z_{33}.

Transfer impedances are obtained by following the procedure outlined for Equations 41, 42, and 43.[3] To find transfer impedance Z_{23}, basic relationships are:

$$F_c = F_b = \left(\frac{F_c}{F_d}\right) F_d$$

$$R_{2o} = M_b F_b = \frac{M_b Z_c F_d}{Z_d}$$

$$M_{23} = \frac{R_{2o}}{F_o} = \frac{M_b Z_c}{Z_d}$$

From the last equation then,

$$Z_{23} = \frac{Z_b Z_d}{Z_c} \quad (59)$$

For transfer impedance Z_{13},

$$F_a = \left(\frac{F_a}{F_o}\right) F_o = \left(\frac{Z_a}{Z_b}\right) F_b = \left(\frac{Z_a Z_c}{Z_b Z_d}\right) F_o$$

$$R_{1o} = M_{m1} F_a = \frac{M_{m1} Z_a Z_c F_o}{Z_b Z_d}$$

$$M_{13} = \frac{R_{1o}}{F_o} = \frac{M_{m1} Z_a Z_c}{Z_b Z_d}$$

or

$$Z_{13} = \frac{Z_{m1} Z_b Z_d}{Z_a Z_c} \qquad (60)$$

Equations 59 and 60, and the equations used to obtain these transfer impedances, are general and can be expressed in terms of displacement, velocity, or acceleration. Values of Z_{V33}, Z_{V23}, and Z_{V13} are calculated on a velocity basis and plotted as Fig. 18 to give the velocity-impedance response spectrum. An impedance value of zero indicates a resonant condition because velocity impedance is the ratio of F_o/v_o. By contrast, a high impedance indicates a nodal or zero response.

Response Curves: Before the interesting features of Fig. 18 are examined, natural frequencies of the systems and subsystems will be found.

The natural frequencies of the systems in Fig. 17 are roots of

$$\omega^2 \left[\omega^4 \left(\frac{m_1 m_2 m_3}{k_1 k_2} \right) - \omega^2 \left(\frac{m_1 m_2 + m_1 m_3}{k_1} + \frac{m_1 m_3 + m_2 m_3}{k_2} \right) + (m_1 + m_2 + m_3) \right] = 0$$

Substituting numerical values into this equation gives system natural frequencies of 0, 500, and 1500 rad per sec. Because the system is being driven at disc J_3 or mass m_3, rather than vibrating freely, these system frequencies are not the only resonant conditions present.

When the center disc or mass does not vibrate, the two end discs or masses vibrate at a natural frequency based on Fig. 19, or

$$\omega_n = \left(\frac{k}{m}\right)^{1/2} = \left(\frac{10^6}{4}\right)^{1/2} = 500 \text{ rad per sec}$$

If disc J_3 or mass m_3, Fig. 17, does not move, the natural frequencies of the rest of the system, Fig. 20, are given by Equation 36[3]: ω_n = 344 and 1460 rad per sec.

When the impressed frequency is 1500 rad per sec, note in Fig. 18 that Z_{V13}, Z_{V23}, and Z_{V33} all equal zero. For this condition, the inertias have infinite amplitudes.

When the impressed frequency is 500 rad per sec, it corresponds to one natural frequency of free vibration of the entire system in Fig. 17 and also to the natural frequency of k_1 and m_1, or k_2 and m_2, in Fig. 19. At this frequency, the end discs vibrate with infinite amplitudes since Z_{V33} and Z_{V13} equal zero. Also, because they are of opposite sign, Z_{V33} and Z_{V13} vibrate out of phase.

When impressed frequency is 344 rad per sec (ω^2 = 118,000), the velocity impedance of disc J_3 becomes infinite, thus indicating that this disc becomes stationary. For this case, examination of a Holzer table, as given in Table 6, reveals several points of interest. Note from Fig. 18 that Z_{V13} = 1550 lb-sec per in. when ω = 344 rad per sec. Since $Z_{V13} = F_o/(R_o\omega)$, then R_o = 1000/[1550(344)] = 0.00188. This value is used to start Table 6.

From Table 6, the force or torque remainder is 1000 and the amplitude of disc J_3 is zero, which agrees with Fig. 18. The torques or forces listed in Table 6 for discs J_1 and J_2 are 882 and 118, respectively. Their sum equals the impressed excitation of 1000 given for the systems in Fig. 17. A similar situation exists at a frequency of 1460 rad per sec. The chief difference is that then the motion of discs J_1 and J_2 are out of phase.

In Fig. 18, the sign of the combined impedance curve always changes when impedance goes through a point at zero or infinity. Although difficult to see because of the narrow frequency range, there is a curve of Z_{V33}, which is negative, between frequencies 1460 and 1500 rad per sec.

At low frequencies, all impedance lines become asymptotic to an impedance line based on the sum of the three mass impedances. This convergence of impedance lines indicates that, at the lower frequencies, the three masses tend to move as a unit. At high frequencies, above 2000 rad per sec, the Z_{V33} line is asymptotic to the Z_{Vm3} line. This condition indicates that, at the high frequencies, disc J_3 or mass m_3 moves as if only it were present.

Normal-Mode Mobility Method: The procedure for finding response of multiple-mass systems by the normal-mode mobility method follows the procedure outlined for a two-degree-of-freedom system.[3] As the number of degrees of freedom increases, the number of natural frequencies and normal modes also increases, but the method of analysis is the same.

Amplitudes of the masses for free vibration of the systems in Fig. 17 are,

$$x_{2o} = x_{1o}\left(1 - \frac{m_1\omega^2}{k_1}\right) \qquad (61)$$

$$x_{3o} = \frac{x_{2o}}{1 - \dfrac{m_3\omega^2}{k_2}} \qquad (62)$$

When the amplitude of mass m_1 is assigned a value of +1, amplitudes of free vibration for the other masses may be found by substituting numerical values into Equations 61 and 62. Results are listed in Table 7.

Expressions for the mobilities, similar to Equations 50 and 51,[3] are:

$$|M_{V13}| = \frac{M_{Vo13O}}{\beta_O - \dfrac{1}{\beta_O}} + \frac{M_{Vo13I}}{\beta_I - \dfrac{1}{\beta_I}} + \frac{M_{Vo13II}}{\beta_{II} - \dfrac{1}{\beta_{II}}} \qquad (63)$$

$$|M_{V23}| = \frac{M_{Vo23O}}{\beta_O - \dfrac{1}{\beta_O}} + \frac{M_{Vo23I}}{\beta_I - \dfrac{1}{\beta_I}} + \frac{M_{Vo23II}}{\beta_{II} - \dfrac{1}{\beta_{II}}} \qquad (64)$$

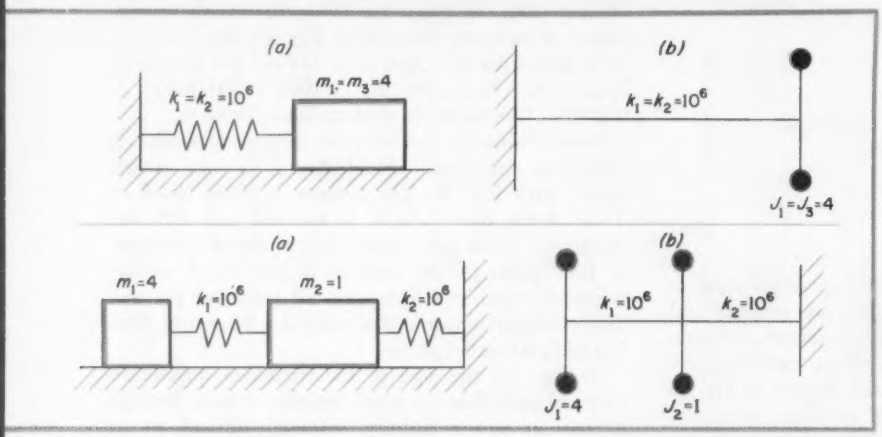


Fig. 19—System diagram for finding natural frequency of remainder of systems in Fig. 17 when center mass or disc does not vibrate. Diagram *a* corresponds to Fig. 17*a*, diagram *b*, to Fig. 17*b*.

Fig. 20—System diagram for finding natural frequencies of systems in Fig. 17 when the driven mass or disc does not move. Diagram *a* corresponds to Fig. 17*a*, diagram *b*, to Fig. 17*b*.

Table 8—Effective Masses and Spring Gradients for Normal Modes*

Mode	ω_i	m_{i33}	m_{i23}	m_{i13}	k_{i33}	k_{i23}	k_{i13}
O	0	9	9	9	0	0	0
I	500	8	∞	−8	$2(10)^6$	∞	$-2(10)^6$
II	1500	72	−9	72	$162(10)^6$	$20.25(10)^6$	$162(10)^6$

*Based on systems in Fig. 17.

$$|M_{V33}| = \frac{M_{Vo33O}}{\beta_O - \frac{1}{\beta_O}} + \frac{M_{Vo33I}}{\beta_I - \frac{1}{\beta_I}} + \frac{M_{Vo33II}}{\beta_{II} - \frac{1}{\beta_{II}}} \quad \ldots (65)$$

Driving-point effective masses are found with an equation similar to Equation 52[3]:

$$m_{i33} = \frac{m_1 x_{1o}^2 + m_2 x_{2o}^2 + m_3 x_{3o}^2}{x_{3o}^2} \quad (66)$$

where values of x_{1o}, x_{2o}, and x_{3o} for the various modes are taken from Table 7. Transfer effective masses are given by expressions similar to Equation 54[3]:

$$m_{i23} = \frac{m_1 x_{1o}^2 + m_2 x_{2o}^2 + m_3 x_{3o}^2}{x_{3o} x_{2o}} \quad (67)$$

$$m_{i13} = \frac{m_1 x_{1o}^2 + m_2 x_{2o}^2 + m_3 x_{3o}^2}{x_{3o} x_{1o}} \quad (68)$$

Numerical values of the effective masses may be found by substituting values of masses from Fig. 17 and values of amplitudes from Table 7 in Equations 66, 67, and 68. Corresponding effective spring gradients can then be computed with Equation 53[3] ($k_i = m_i\omega_i^2$). Calculated results are listed in Table 8.

Velocity mobilities, plotted on Fig. 21, are obtained by substituting values from Table 8 in Equations 9 and 10.[1] In Fig. 21, spring and mass velocity mobilities (long dash) and modal response (short dash), which is drawn with a template, are added algebraically to obtain the combined velocity-mobility curves (solid) for M_{V13}, M_{V23}, and M_{V33}.

Center Excitation

The component mobility method will now be applied to a three-mass system with center excitation. Revising Fig. 17*b* so that the system is driven at the center mass gives the system shown in Fig. 22*a*. The schematic diagram is then changed from Fig. 17*c* to Fig. 22*b*. Points *a*, *b*, and *c* in Fig. 22*b* all have a common motion, and therefore the action is parallel. The end masses and their springs act in series.

For the schematic diagram, Fig. 22*b*, mobility and impedance relationships are:

$$M_a = M_{s1} + M_{m1} \quad (69)$$

$$M_b = M_{s2} + M_{m3} \quad (70)$$

$$Z_c = Z_a + Z_b + Z_{m2} \quad (71)$$

Impedance at point *c*, representing the response function at mass m_2 resulting from a force applied at this point, is the driving-point impedance.

Transfer impedances are obtained by following the procedure for Equations 59 and 60. Thus,

$$F_a = \left(\frac{F_a}{F_o}\right) F_o = \left(\frac{Z_a}{Z_c}\right) F_o$$

$$R_{1o} = M_{m1} F_a = \frac{M_{m1} Z_a F_o}{Z_c}$$

$$M_{12} = \frac{R_{1o}}{F_o} = \frac{M_{m1} Z_a}{Z_c}$$

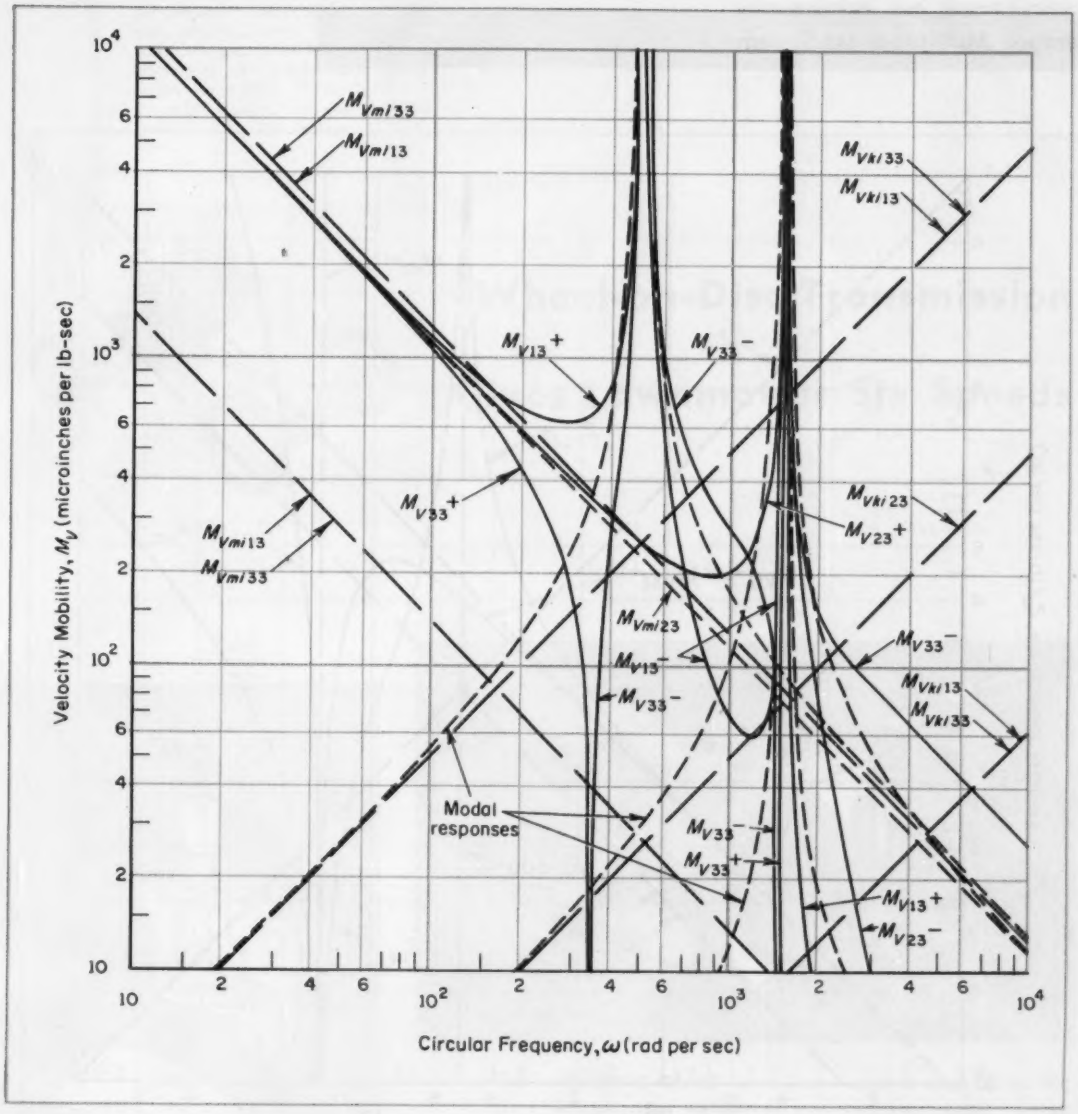


Fig. 21—Velocity-mobility spectrum for normal-mode mobility method of analyzing the systems with end excitation shown in Fig. 17.

or

$$Z_{12} = \frac{Z_c Z_{m1}}{Z_a} \tag{72}$$

Similarly,

$$Z_{32} = \frac{Z_c Z_{m3}}{Z_b} \tag{73}$$

Because of symmetry of the numerical values in Fig. 22*a*, $Z_a = Z_b$ and $Z_{m1} = Z_{m3}$. Substituting these terms into Equation 72 shows that $Z_{12} = Z_{32}$. Also, substituting Z_a for Z_b in Equation 71 shows that driving-point impedance is

$$Z_{22} = 2Z_a + Z_{m2} \tag{74}$$

Calculated values of velocity impedances Z_{V12},

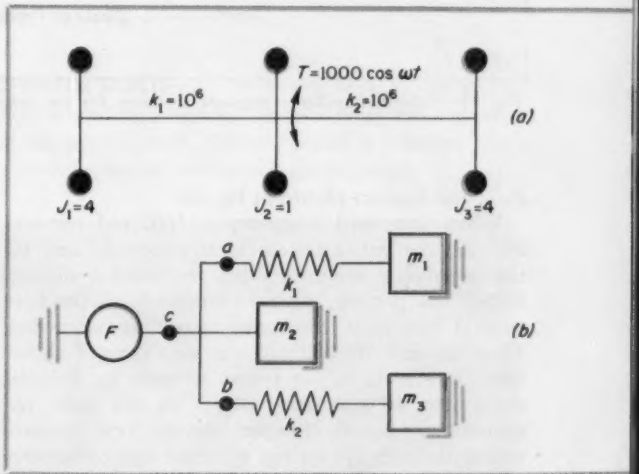


Fig. 22—Three-mass elastic system with center excitation. Torsional system, *a*, is revision of system in Fig. 17*b*. Schematic mobility diagram for *a* is shown at *b*.

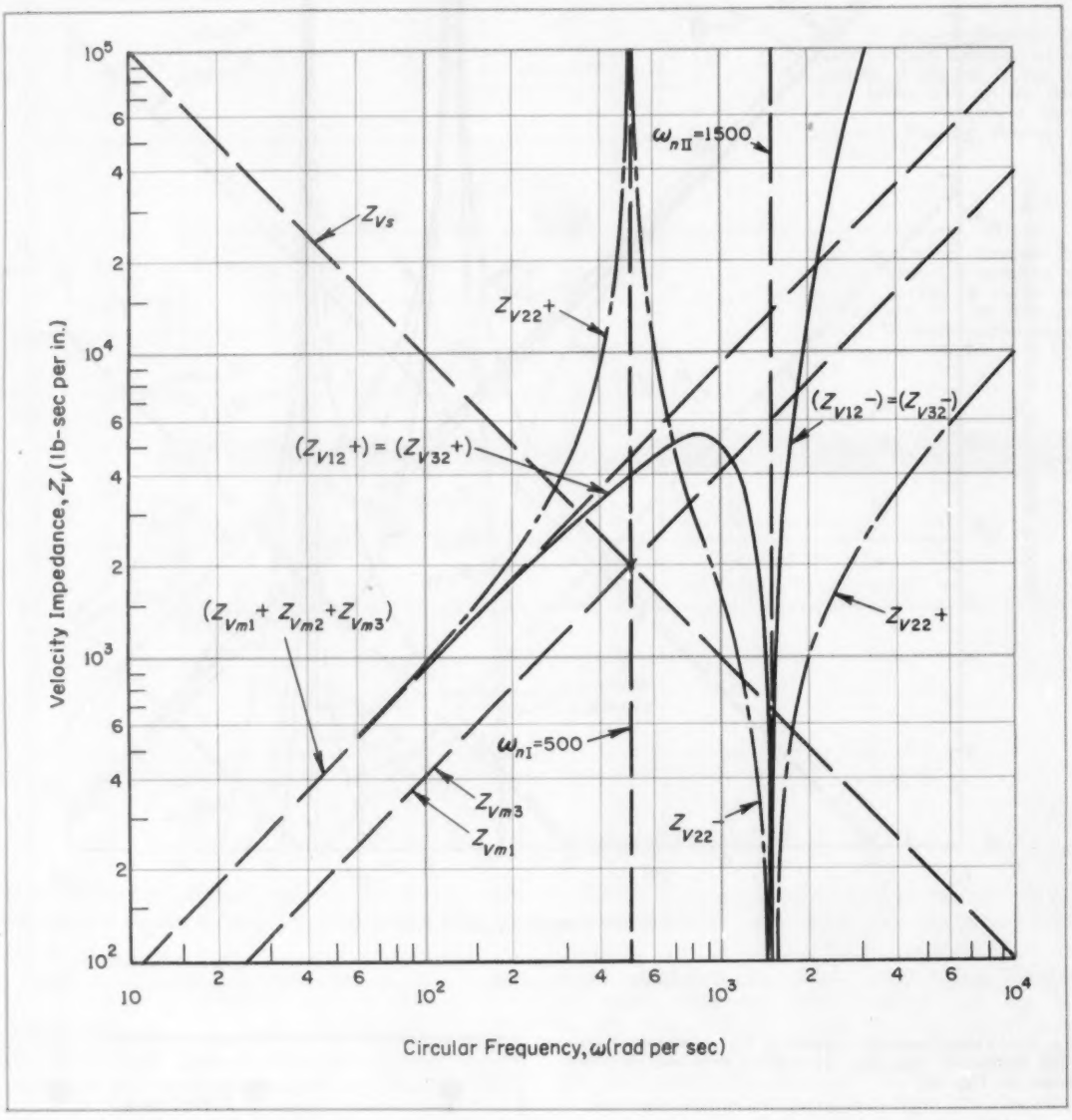


Fig. 23—Velocity-impedance response spectrum for the three-mass system with center excitation shown in Fig. *22b*.

Z_{V22}, and Z_{V32} are plotted in Fig. 23.

When impressed frequency is 1500 rad per sec, Fig. 23, the entire system is in resonance and all the impedances are zero. When impressed frequency is 500 rad per sec, which corresponds to the first natural frequency, the center mass has no motion ($Z_{V22} = \infty$). At 500 rad per sec, Table 7 shows there is a node in the system at mass J_2. Because the system is then being driven at this node, response there is zero. However, exciting force is transmitted through the springs to create equal responses at masses J_1 and J_3 (Z_{V12} and Z_{V32}).

The response spectrum in Fig. 23 could also be found by using the normal-mode mobility method. However, since no new concepts would be involved, the procedure will not be presented.

Next article in this series will discuss methods for handling coupled systems, determining natural frequencies of complex systems, and evaluating the effect of support flexibility on natural frequency.

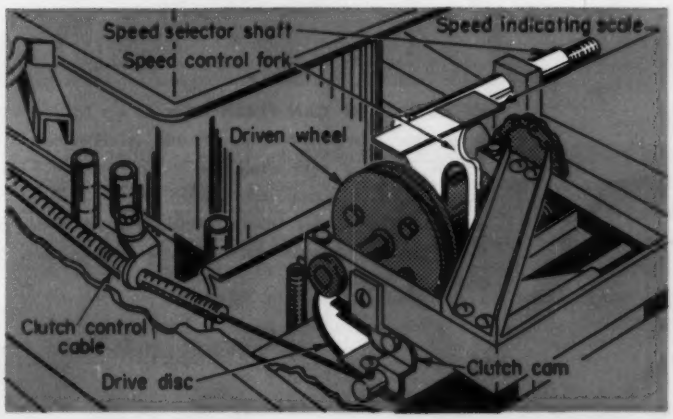
References

This article is the fourth in a series by Austin H. Church on simplified vibration analysis. Previous articles and issues of Machine Design in which they appeared are:

1. "Mobility and Impedance Concepts" .....February 18, 1960
2. "Single-Degree-of-Freedom Systems" .....March 3, 1960
3. "Two-Degree-of-Freedom Systems" .....March 17, 1960

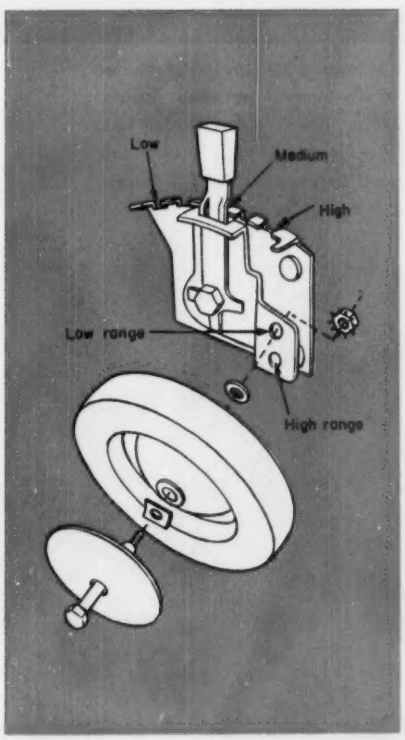
Self-propelled rotary mower with adjustable drive ratio and individual wheel-height adjustments is called the Homko model 1227. It's produced by Western Tool and Stamping Co., Des Moines, Iowa.

Wheel-on-Disc Transmission Gives Lawnmower Six Speeds

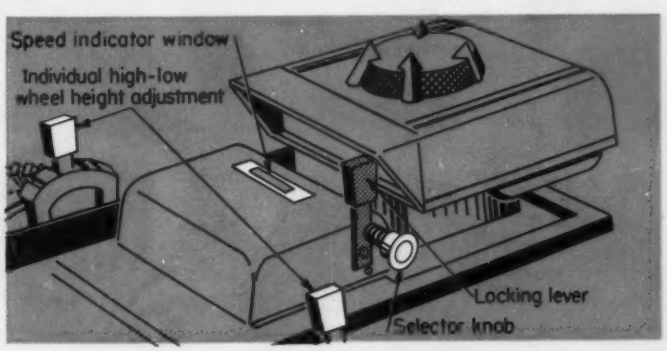


"SHIFTING GEARS" on a lawnmower is done by moving a wheel over the surface of a friction drive disc. Clutch cam, cable-controlled from handle of mower, disengages drive by lifting driven wheel.

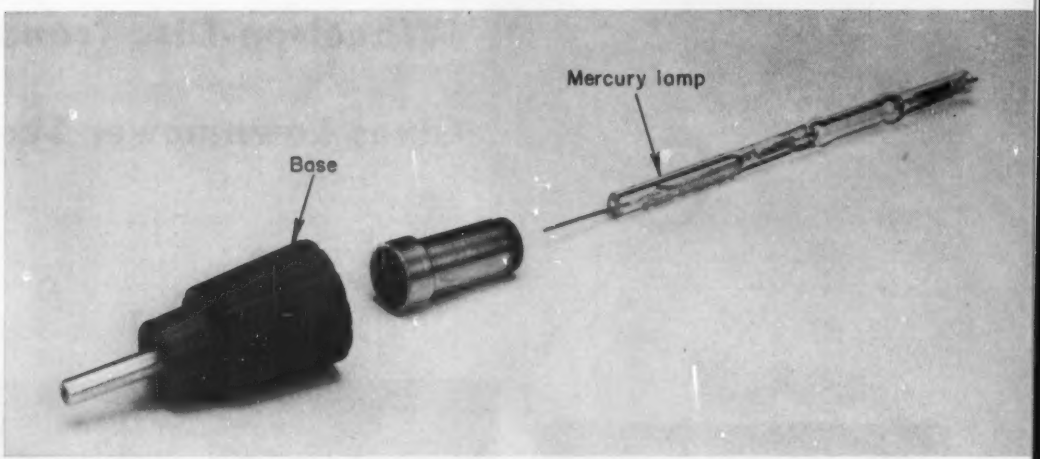
OPERATOR SELECTS ratio by moving knob to one of six discrete positions where locking lever drops into a groove on the selector shaft. Selected speed is indicated in a window on top of the transmission housing.



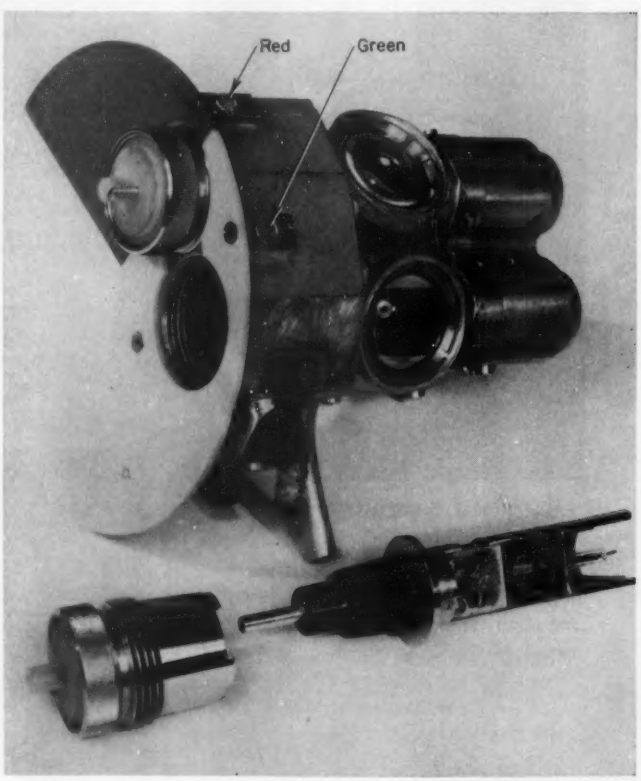
EACH WHEEL IS ADJUSTED for height independently by its own quick-setting lever with five click stops. By removing the wheel and changing a mounting bolt, the user acquires a new range of five quick-set heights.



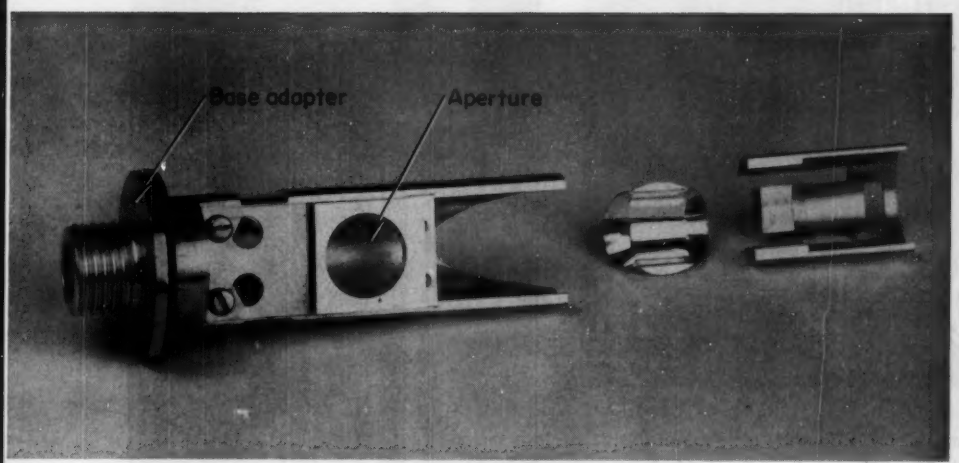
Blinking Lamp Eliminates Movie-Projector Shutter



MERCURY LAMP CAN FLASH at rates up to 100 cps, eliminating the revolving shutter in a new movie projector. Frame is changed in 1/96-sec interval between flashes. Actual flashing rate used for movie projection is 72 cps, giving three flashes per frame for less appreciable flicker in the picture than with standard projectors which give two flashes per frame (standard shutters are designed to interrupt the light beam twice per cycle, once during frame change and once between changes to minimize annoying flicker).



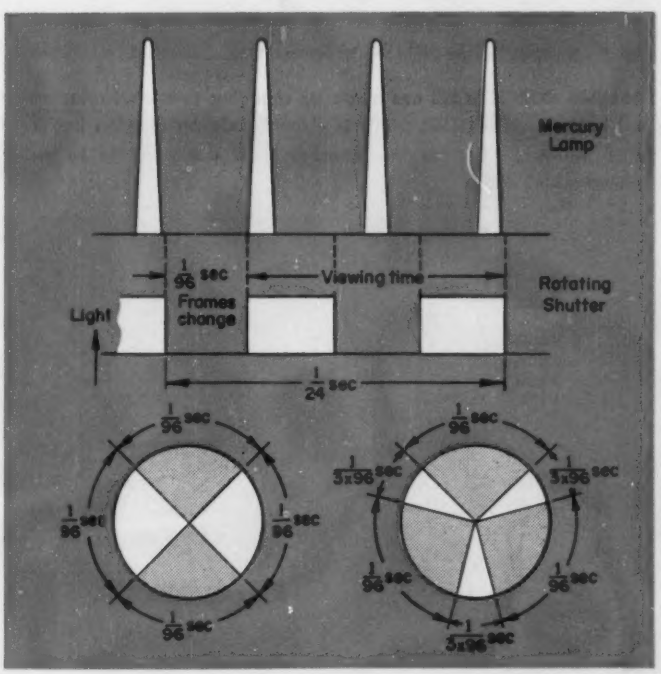
LAMP TURRET ROTATES to new lamp position automatically in case of lamp failure. Changeover is so quick audience cannot perceive the blink. It's done by gravity. First lamp is held in position by a pawl that trips when lamp current fails. Color section on turret warns operator when change has occurred. Water and electric connections line up when lamp is in projecting position.



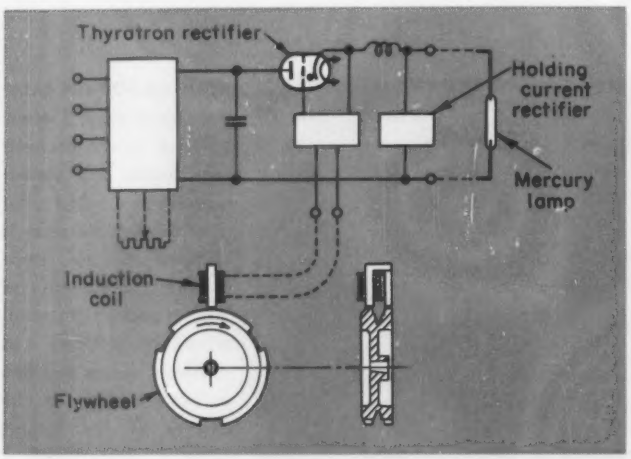
HOUSING FOR THE LAMP includes cylindrical reflector and filters to keep out harmful and useless wavelengths. One filter is ultraviolet; the other is matched to the transmissibility of the lens and holds back light that would be trapped and add heat to lens and film without adding to the quality of the image. Lamp is water-cooled.

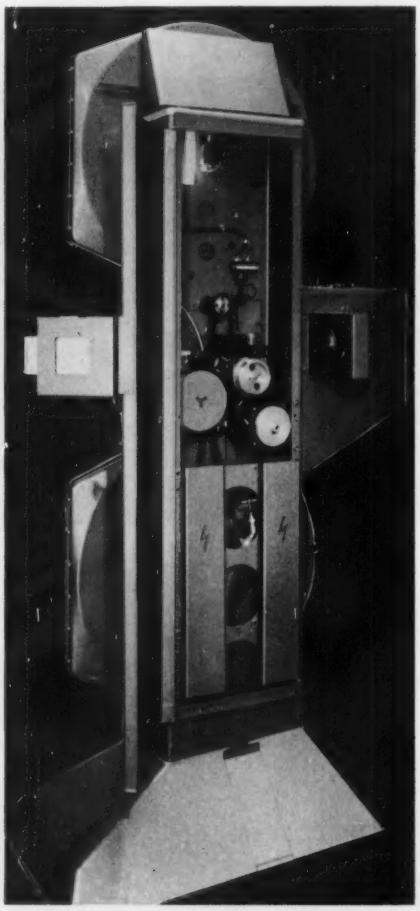
Pulsed-light projector, described by P. Hoekstra, C. Meyer, and J. J. Kotte in *Philips Technical Review* for Dec. 31, 1959, is a development of Philips Research Laboratories and is produced by N. V. Philips Gloeilampenfabrieken, Eindhoven, Netherlands.

ALL THE LIGHT coming from the mercury lamp is used in picture projection. Circle diagram shows what happens to the light of a standard projector when three flashes per frame is attempted. Instead of using one-half of the produced light as present projectors do, it would use one-fourth. Tests show the mercury lamp has an efficiency of about 6 lumens per watt with an f2 lens. Efficiency of a carbon arc with a standard shutter is about 2.5 lumens per watt.



Blinking Lamp Eliminates Movie-Projector Shutter

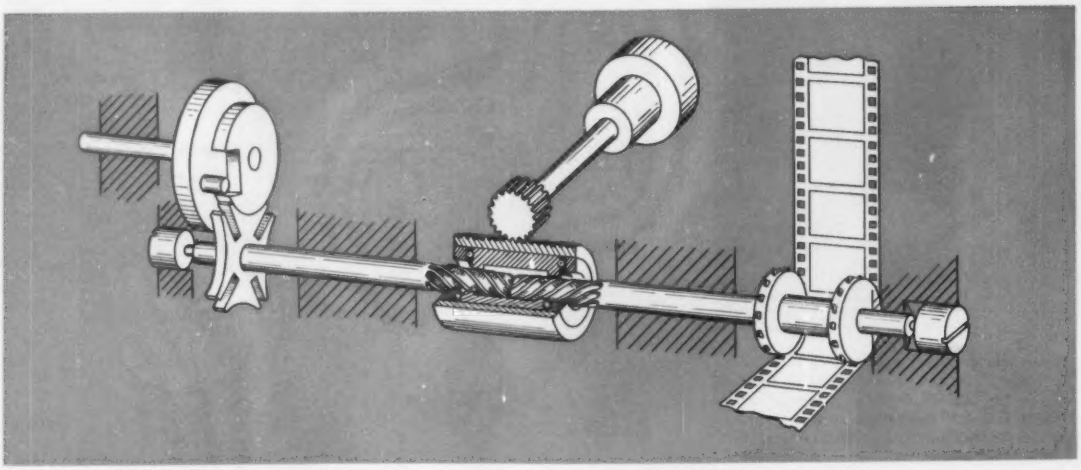




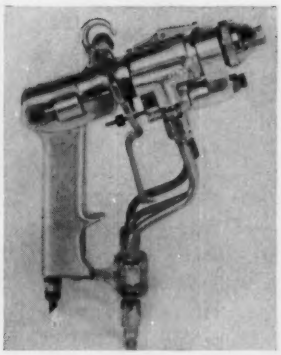
PULSING OF MERCURY-LAMP current is done by a thyratron rectifier. Grid of thyratron is controlled by induction from flywheel of geneva wheel in film-transport system.

PROJECTOR COMPONENTS are mounted on a vertical sheet-metal column of new design. They are automatically lined up by the flat, vertical mounting panel. Object of the design is to develop a projector body flexible enough to allow adding or replacing components to match the demands of the user, or to keep up with new developments. It can be equipped with the new pulsed light, or with conventional units using shutters. All models are equipped with an optical sound head, but a slight adjustment permits addition of a magnetic soundhead as well.

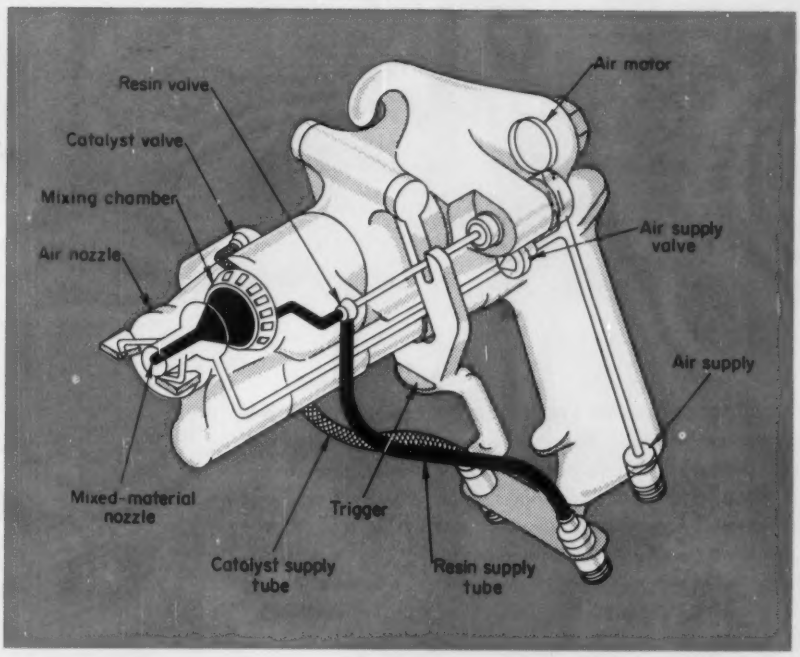
FRAMING CORRECTIONS are made by changing rotational relationship of geneva wheel and intermittent sprocket. This is done by sliding a nylon bushing along two sets of spiral lands. Those on the sprocket shaft are opposite in sense to those on the geneva wheel shaft.



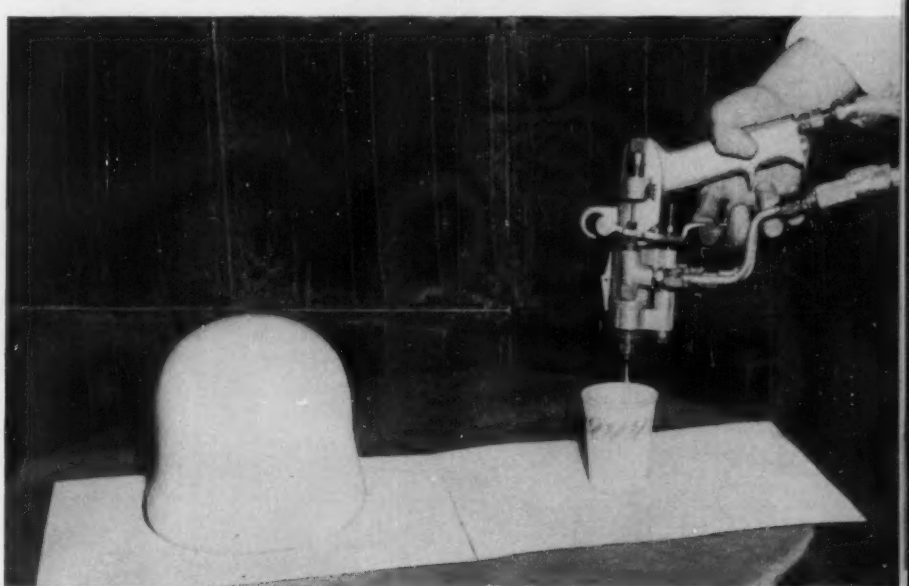
Roller Bearing Mixes Two Materials In Spray Gun Designed for Plastics



APPLICATIONS WAITING for the production of this gun, say the producers, Binks Manufacturing Co., Chicago, include tank linings, coating structural steel, boats, swimming pools, building surfaces, and cushioning.



DRIVEN BY AIR MOTOR, a high-speed tapered roller bearing thoroughly mixes active agent and catalyst as they are forced through it under pressure. This instant, thorough mixing assures uniform, high quality of plastics delivered through a new spray gun designed for applying various kinds of plastic coatings. Gun can be used for "no solvent," 100 per-cent solid plastics, or for certain mechanical foaming or self-foaming applications.

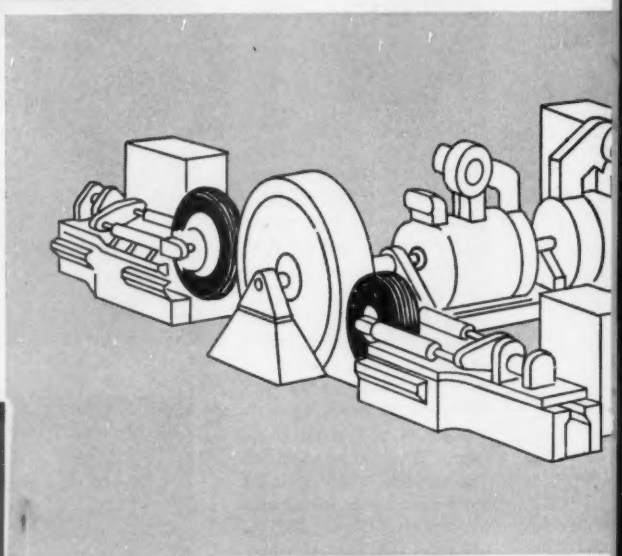


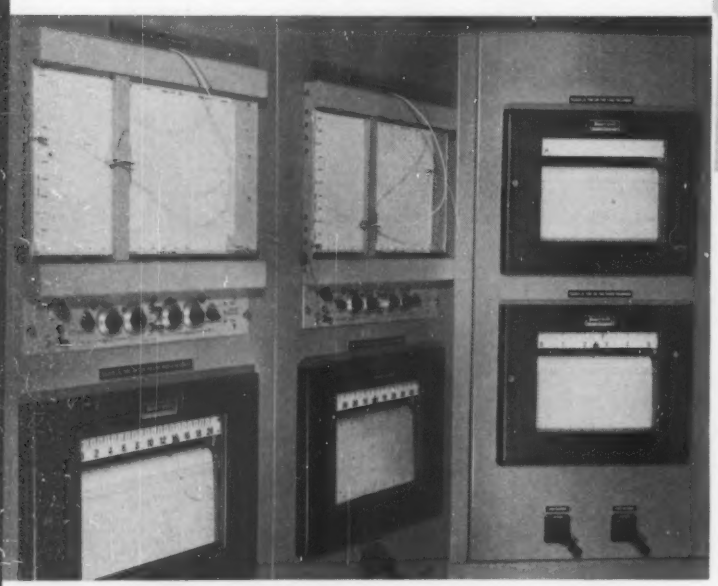
FOAM-IN-PLACE materials are "poured" from the gun with atomizing air hose detached. Instant mix of roller bearing retains full reactive power of the ingredients. Foam mushroom, left, was made by pouring ingredients into paper cup, right.

Remote Controls Operate Giant Tire Tester

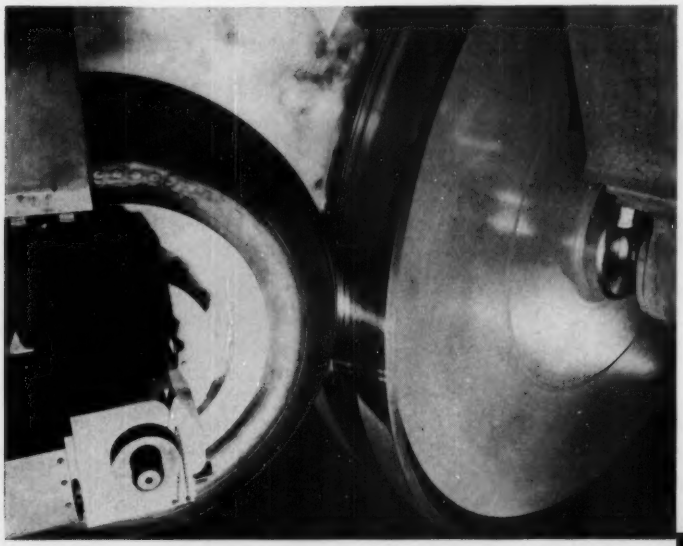
TESTING PERSONNEL ARE protected from fragments of flying tires by a concrete-block wall while they program destructive tire tests on a new testing facility at Goodyear. Test can be watched on closed circuit television, while charts and timers give a history of the test.

PROGRAMMERS ARE X-Y RECORDERS adapted to follow a copper line glued to the chart. **X** motion is a function of time controlled by a servomotor. **Y** motion is controlled by a "sniffer," a small coil that senses the magnetic field caused by passing a 1-amp 60 cycle current through the wire "plot." A potentiometer gives an instantaneous indication of the sniffer's position; its signal controls the machine.



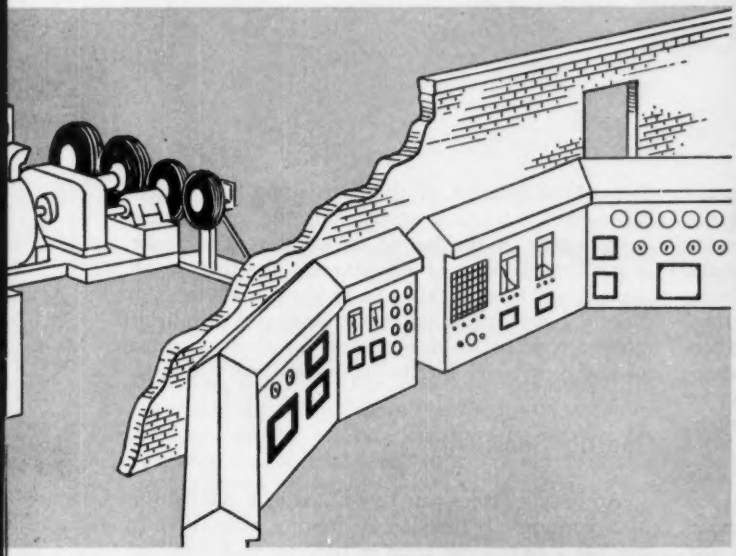


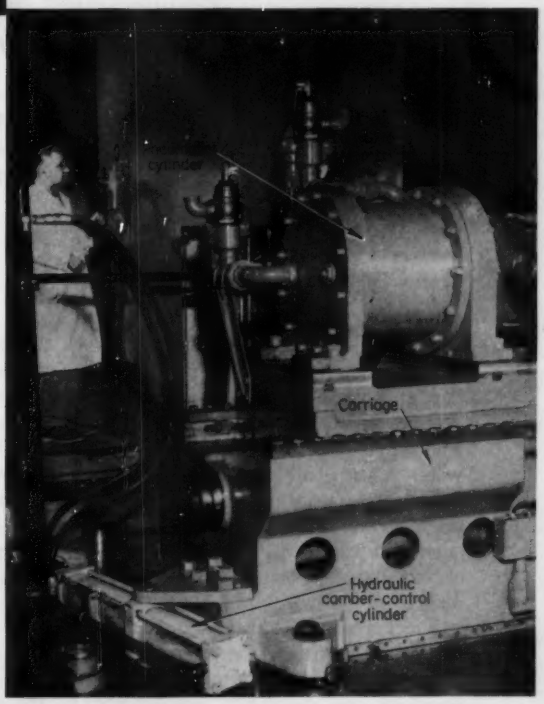
POWER TO DRIVE tire tester comes from two 1298-hp dc motors mounted in tandem. Motors can drive either the 10-ft flywheel at the left, or the tire-on-tire test at the right, but not both at once. Dynamometer was built for Goodyear by Adamson United Co.



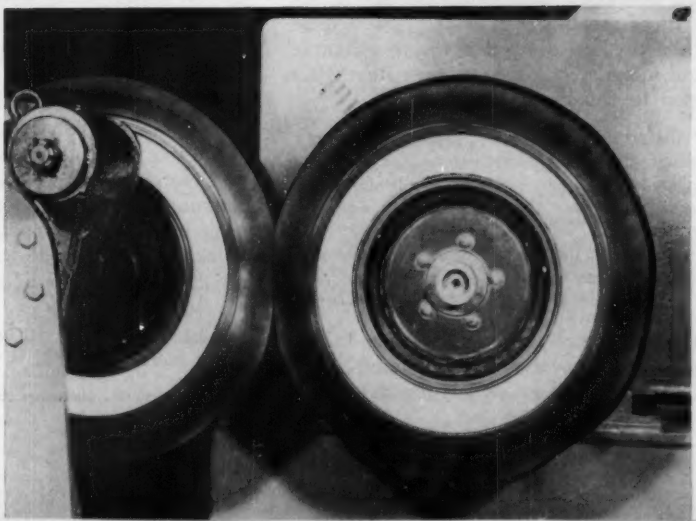
CAMBER IS PRODUCED by a hydraulic cylinder mounted transversely at the rear of the test carriage. The carriage swivels around a hinge pin located just under point of contact of tire and flywheel. Pneumatic cylinder on the carriage drives tire against flywheel with proper force.

FLYWHEEL SIMULATES RUNWAY for airplane take-off and landing tests. Speeds on this "runway" can reach 300 mph. Camber and yaw up to 15 degrees can be produced to test the effects of side loads on an airplane tire.





TIRE-ON-TIRE TEST can generate surface speeds of 500 mph. Most present auto tires withstand about 300 mph before bursting. Goodyear engineers claim tire-on-tire test is a more accurate representation of road conditions because equal yielding of two tires produces a flat interface more like a flat roadbed than any type of flywheel.



Testing Inertia-Sensitive Devices

Kinds of Shock Activation
Typical Sensitivity Curves
Relative Effect of Gravity
Comparison of Test Methods

V. F. DeVOST and G. STATHOPOULOS
Environment Simulation Div.
U. S. Naval Ordnance Laboratory
White Oak, Silver Spring, Md.

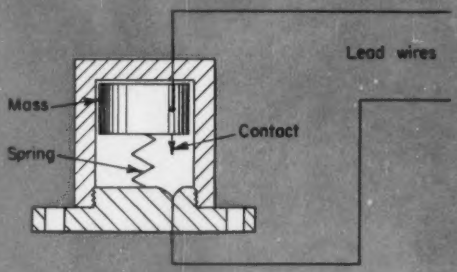


Fig. 1—Simple inertia device.

IN RECENT years, the field of shock testing has grown and flourished, primarily because of the high reliability requirements of advanced weapons. A weapon in service may be subjected to shocks associated with rough handling, target impact, water entry, atmospheric re-entry, maneuvering, launching, countermeasures, parachute drag, and aircraft ejection. Each of these shocks differs in character and intensity. Only one or two or three may be critical for a particular weapon; the others may be disregarded.

Shock testing techniques usually aim to simulate one of the critical shock environments a weapon or component is expected to encounter in service. Facilities are developed accordingly to shock test the component or the full size weapon. Such facilities have been used to determine the performance and structural integrity of a development item while it is subjected to shocks that:

1. Simulate the service environment, thereby satisfying the minimum reliability requirements.
2. Oversimulate the service environment, thereby obtaining added confidence that the reliability requirements are satisfied.
3. Grossly oversimulate the service requirements, inducing failures which are assessed for possible redesign, and analyzed for safety aspects.

Important as the shock testing of weapons is during development and evaluation, of almost equal importance, and less well known, is the shock testing and evaluation of the inertia-sensitive devices themselves. In this application, the quantitative performance of the inertia device is studied under a wide range of shock conditions. The theory and techniques[1] used in this area of work and a description of a new laboratory tester developed to provide greater precision in determining the shock response of highly sensitive inertia devices are outlined here.

Inertia Sensitivity

An inertia device can be defined as a mechanism that performs its function by moving some distance against a restraining force in response to a transient forcing function. The forcing function is an acceleration pulse acting on the mass, and the restraining force is exerted by an elastic member.

An example of a simple inertia device is a single-degree-of-freedom mass-spring system, Fig. 1. The acceleration pulse is generated by the deceleration or acceleration of the vehicle on impact or launch, and the mass compresses the spring under its own inertia force until electrical contact is made. As a practical point, most inertia devices are restrained to operate on either acceleration or deceleration.

Test Philosophy: In determining the performance of an inertia device it is sometimes deemed adequate

[1]References are tabulated at end of article.

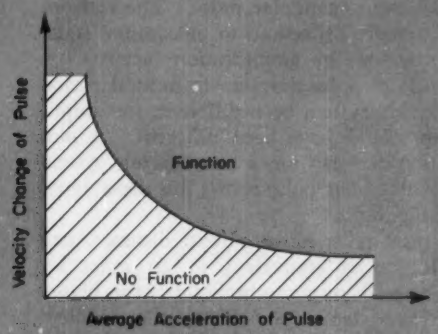


Fig. 2—Typical inertia-sensitivity curve.

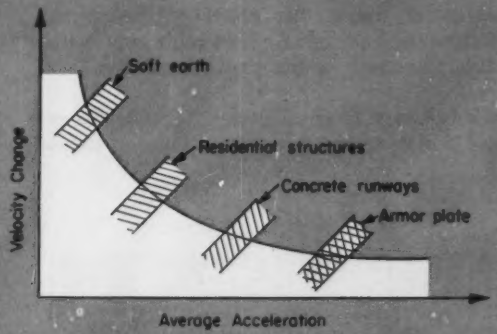


Fig. 3—Representative target impacts located on an inertia sensitivity curve.

to determine whether or not the device will function properly under one given set of operating conditions. As an example, for a projectile impact-firing switch, a go or no-go test of the projectile striking a given target at a certain angle and velocity may be considered an evaluation of the firing switch.

However, this type of test does not explore the full potentialities of the switch in that application (namely, the "quantitative" sensitivity or minimum striking velocity to fire), nor does it examine the performance of the switch under other operating circumstances, such as other types of targets or use in other projectiles. Further, most devices originally conceived for one specific purpose often end up being used for other applications. Additionally, the true shock environment rarely can be defined accurately. So it is desirable to know the performance of the mechanism under any set of circumstances.

Sensitivity Curve: The acceleration-time history of the device entirely describes the input pulse. Basic parameters are the acceleration, velocity change, and duration. The activating pulse consists of the local acceleration-time history at the housing of the inertia device, and the response is independent of the initial velocity of the weapon, i.e., the device cannot differentiate between a sudden change in velocity from 1000 to 980 fps and one from 20 fps to rest.

The sensitivity curve for a single-degree-of-freedom system (such as the firing switch) in response to simple acceleration-time pulses in a given direction will generally be similar to Fig. 2. This curve makes the prediction that when the velocity change and average acceleration of the input pulse can combine to define a point in the crosshatched region, the device will not function. Basically, this single curve completely defines the sensitivity of the mechanism to inertial actuation.

The sensitivity curve for a firing switch indicates the minimum velocities required for firing at all angles of impact and all degrees of target rigidity (which affects the peak acceleration of the pulse). Individual sensitivity curves are usually indicated for each direction of acceleration, since few mechanisms have identical properties in all directions. Fig. 3 indicates how the properties of the target are typically reflected in the sensitivity curve for a hypothetical inertia-actuated firing switch.

Complicating the problem are other phenomena which affect the performance of inertia mechanisms and therefore shift or distort the sensitivity curve. One factor that makes difficult any attempt to employ a single sensitivity curve or narrow band for all service conditions is the shape of the acceleration-time pulse. That is, a square pulse, a half-sine pulse, and a triangular pulse will all produce sensitivity curves different in some regions, even though the velocity changes and average accelerations are identical. This problem represents an inherent difficulty in the accurate but general

presentation and application of inertia - sensitivity data, and is considered in detail later.

Theoretical prediction has an important role in design and development work. However, experience has shown that it should not be used as a substitute for laboratory evaluation. Effects such as nonlinearity of the spring, preset of the spring, friction, damping, may be of considerable importance in altering the shape of the sensitivity curve.

Sensitivity-Curve Determination: What is the response of a mass-spring system to a pulse of simple shape? Consider the free end of the spring of a mass-spring system, Fig. 1, subjected to a rectangular acceleration pulse. The mass does not follow the forcing function because of the flexibility of the spring, but executes a vibration as in Fig. 4. The peak deflection attained by the mass is different from the deflection which could have been achieved by very slowly applying the maximum value of acceleration of the rectangular pulse. The ratio of maximum dynamic deflection to maximum static deflection is termed the amplification factor.

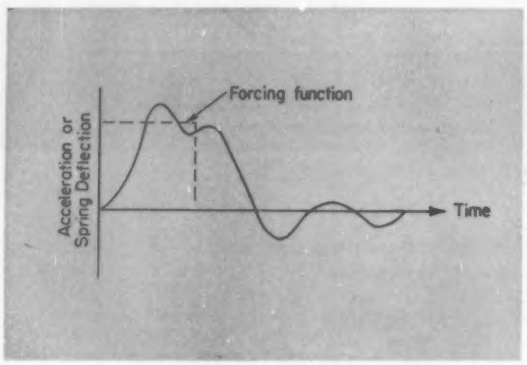


Fig. 4—Response to rectangular pulse.

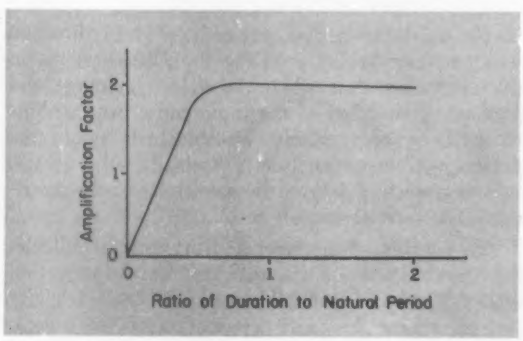


Fig. 5—Amplification factor for rectangular pulses.

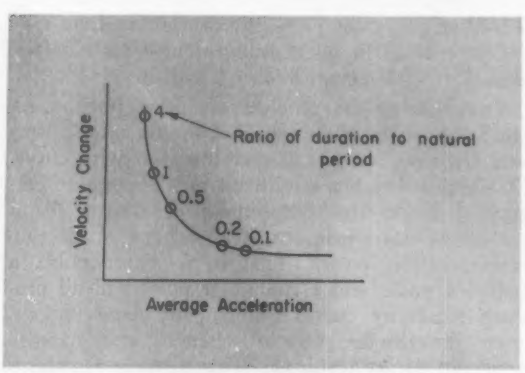


Fig. 6—Inertia-sensitivity curve for rectangular pulses.

Had the ratio of pulse duration to natural period of the mass-spring system been different, the amplification factor would have been different. A plot of amplification factors[2] for a mass-spring system subjected to rectangular pulse shows this dependence on duration, Fig. 5.

Since the mass must move a fixed distance, and a fixed deflection is equivalent to an exact acceleration (the peak response in Fig. 5), the higher the amplification factor the lower the required applied acceleration. For a rectangular pulse, the amplification factor increases as duration increases, soon becoming constant. With regard to velocity change, which is equal to average acceleration times duration, it would appear that longer duration (greater than 0.5 on Fig. 5) signifies greater velocity change. A graphical presentation of these statements is the inertia-sensitivity curve of Fig. 6.

Exception could be taken to the choice of coordinates of Fig 6, since the basic parameters are acceleration and duration. However, the use of velocity change is found to be more practical, since it leads to a curve which quickly approaches two "asymptotes." Actually, for some shape pulses the curve crosses the asymptote, and the rectangular pulse curve actually reaches its asymptote. Velocity change is also an index of the kinetic energy required for actuation.

The reason for the choice of average acceleration instead of peak acceleration is that most service pulses have high-frequency "hash" superimposed on the main pulse. The high-acceleration spikes associated with the hash have little effect on the inertia mechanism, and a plot of peak acceleration would produce erratic and unreliable sensitivity curves.

Interpretation of a Sensitivity Curve: Fig. 6 represents the inertia sensitivity of a mass-spring system to any pulse of rectangular shape. In general, for a given velocity change, it predicts the minimum acceleration necessary to actuate the mechanism. Also, for a given acceleration it predicts the minimum velocity change necessary to actuate the mechanism.

Other conclusions may be drawn from this curve because of the presence of the asymptotes (which also exist for other pulse shapes). Take, for example, the left portion of the curve. In this region of relatively long pulse duration, the velocity change or duration may increase considerably without appreciably changing the acceleration. Similar considerations apply to the right portion of Fig. 6. In this region, as long as the duration of the pulse is about one-third or less of the natural period, the

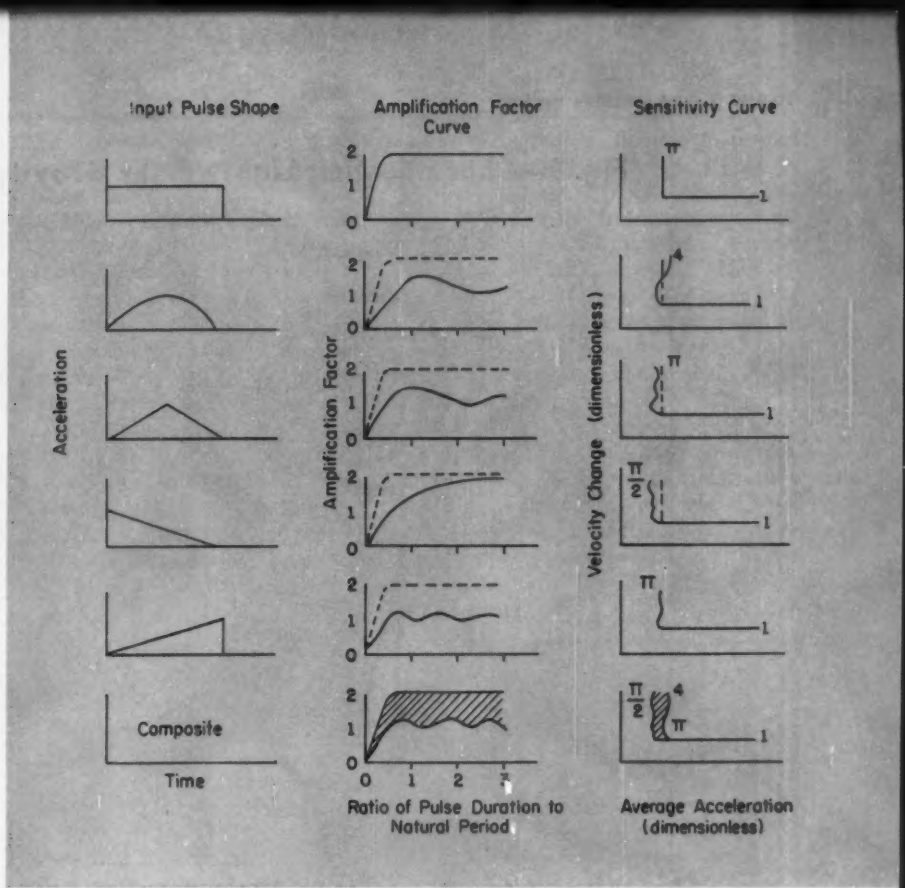


Fig. 7 — Amplification factors and inertia sensitivity curves for single pulses.

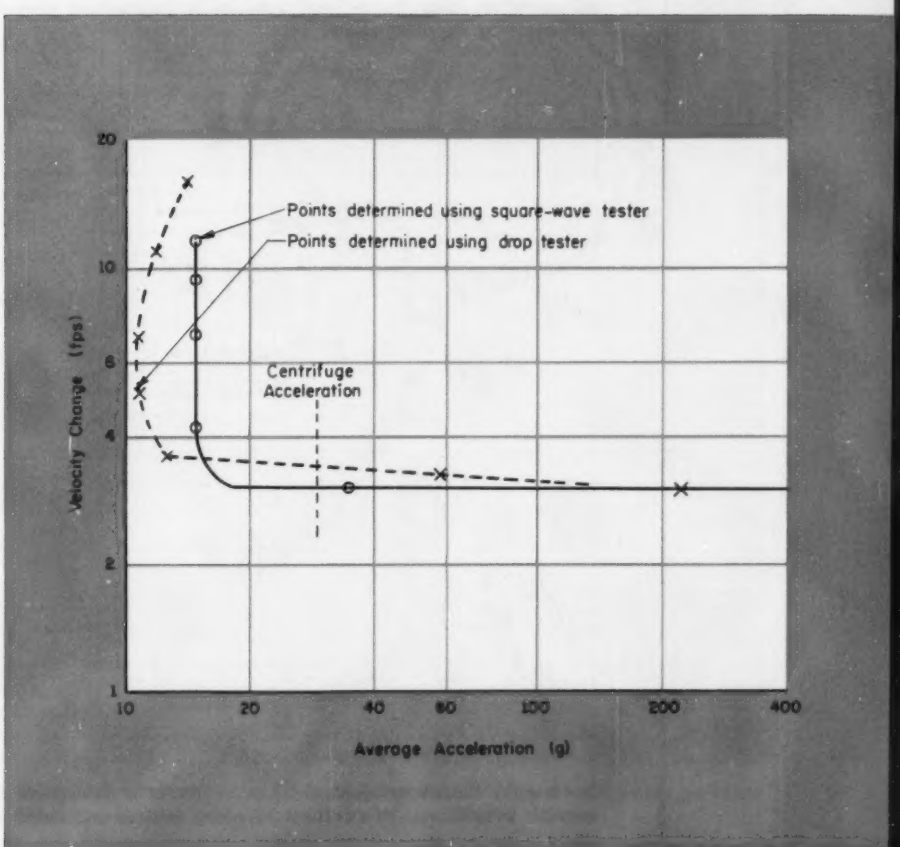
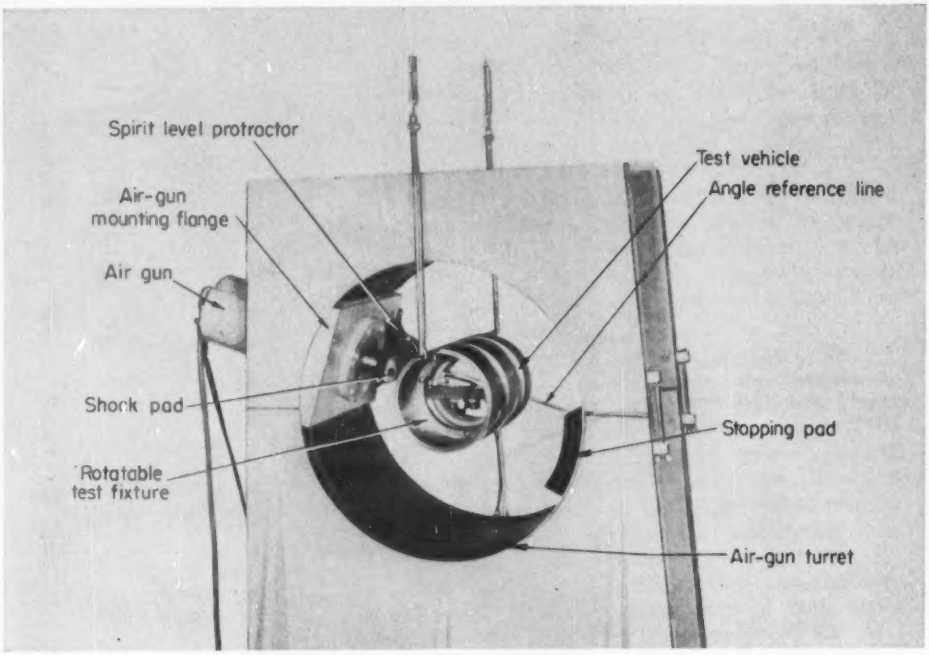
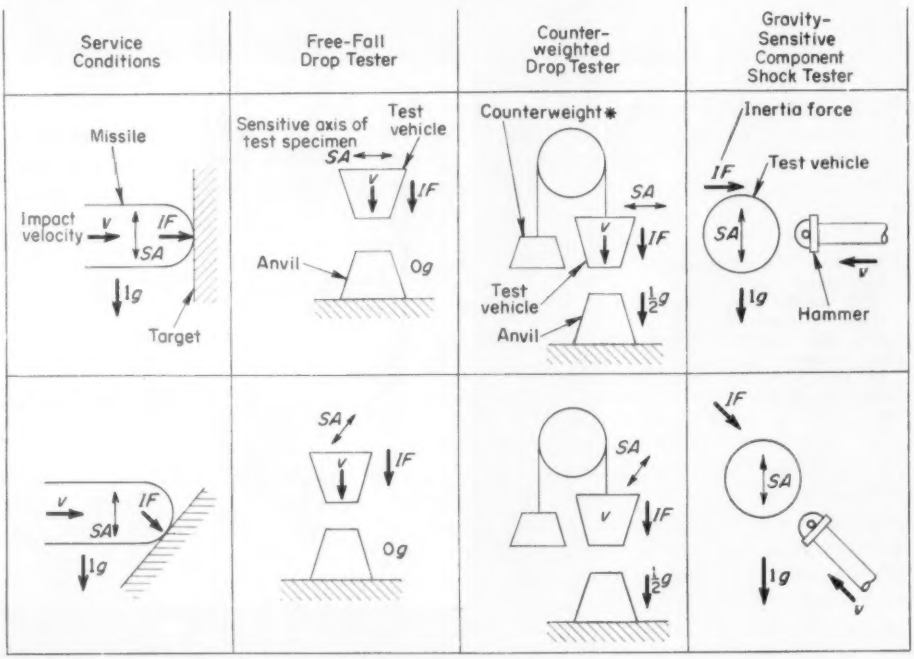


Fig. 8 — Experimentally determined inertia-sensitivity curve. The pulse shape was essentially half sine. The inertia device had a natural period of 50 cps with 0.11 in. travel to close.

Fig. 9—Shock Testing Lightweight Gravity-Sensitive Components



a—Experimental shock tester. Air gun is positioned angularly to strike test vehicle at any desired radial direction. Seismically suspended test vehicle has long period compared to test component fixed inside it. A shock-monitoring accelerometer, also inside test vehicle, is positioned angularly to coincide with direction of applied shock.



*Counterweight 1/3 test-vehicle weight

b—Inertia forces generated by new tester a can have directions identical to service conditions, in contrast to older testers activated by gravity.

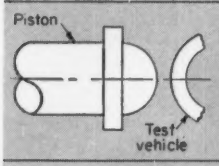
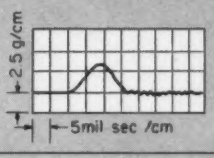
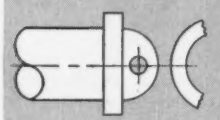
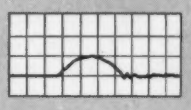
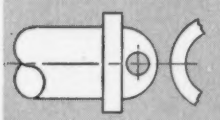
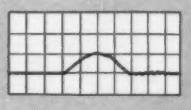
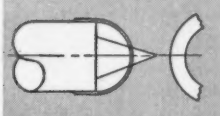
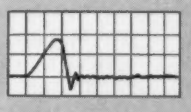
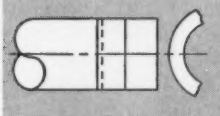
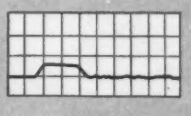
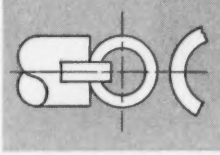
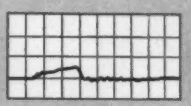
velocity change remains relatively constant. Within this region, the peak acceleration may be unknown or highly variable without affecting the result.

These remarks on asymptotes apply to any sensitivity curve. The quantitative results, however, are different for different pulse shapes. That is, the asymptotes exist but are parallel, Fig. 7. Sensitivity curves for several types of pulses can be compared in an attempt to reach some quantitative conclusions.

How Pulse Shape Affects Sensitivity Curves: Fig. 7 presents sensitivity curves for a mass-spring system subjected to pulses of various shapes. For purposes of comparison, the sensitivity curve for the rectangular pulse is repeated on each plot as a dashed curve. The bottom curve of Fig. 7 is composed of all the sensitivity curves plotted together.

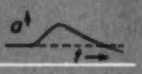
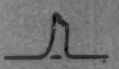
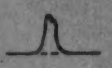
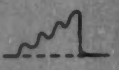
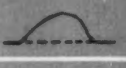
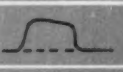
It would be advantageous to be able to employ a single curve, or narrow band, which would be reasonably accurate in many applications. Unfortunately, Fig. 7 reveals variations among single pulses of from $\pi/2$ for the triangle with very short build-up time to 4 for the half-sine pulse. Thus the low-acceleration "asymptotes" spread over a range of nearly 2.5 to 1. The variations for systems which can move in either direction from the neutral position show behavior even less desirable than Fig. 7 when subjected to multiple pulses.

Fig. 7 also shows that pulse shape has little effect on the high-acceleration (short-duration) asymptote. This means that any shock of duration less than 1/3 or 1/4 of the natural period, regardless of pulse shape, will require the same velocity change, or energy, to actuate the inertia device.

Shock Pad	Oscillogram	Acceleration Peak (g)	Time (msec)	Velocity Change (fps)	Firing Pressure (psi)
 35 Durometer rubber, solid		3.5	15	1.02	15
 35 Durometer rubber, $\frac{1}{2}$ in. hole		2.5	18	1.02	16
 35 Durometer rubber, $\frac{3}{4}$ in. hole		2.5	22	1.25	17
 Lead cone (not reuseable) $\frac{1}{2}$ in. diam x 1 in. long 25 per cent crushed		4	9	0.58	17
 Polystyrene pad (not reuseable) $1\frac{1}{2}$ in. diam x 1 in. long 50 per cent crushed		1.75	19	0.819	25
 Lead cylinder (not reuseable) $\frac{3}{4}$ in. OD x $\frac{1}{16}$ in. wall 1 in. long 75 per cent crushed		1.5	16	0.604	15

c—Typical shock characteristics. The oscillograms illustrate shock pulse patterns in the low acceleration range.

Table 1—Characteristics of NOL Test Equipment

Equipment	Peak Acceleration (g)	Duration (msec)	Max Velocity Change (fps)	Pulse Shape
Air guns	5–200,000	1–200	750	
Drop testers (limited to 10 ft drops)				
Steel-on-steel impacts	200–30,000	0.04–0.4	38	
Impact on leather	40–1200	2	38	
Impact on lead pad	10–500	4–12	31	
Impact on rubber pad	3–150	15–40	38	
Square-wave tester	2–60	5–45	25	
Centrifuge	0–1000	Long	Indefinite	

Without going into the questions of which pulse shapes are produced in the laboratory and which pulse shapes may be expected in the field, the following general conclusions may be drawn:

1. The low-acceleration asymptote depends considerably on pulse shape, and is therefore unreliable for general quantitative use. Unless the use of the sensitivity curve is narrowly restriced as to pulse shape, this asymptote is useful only for order-of-magnitude.
2. The high-acceleration asymptote is quite independent of pulse shape and therefore quite reliable.

Laboratory Determination of Sensitivity: The obvious answer to the problem of pulse shape is a laboratory-determined sensitivity curve for each pulse shape likely to be encountered by the inertia device. This, however, is sometimes prohibitive, both in testing time and in equipment. The practical approach is to use the best equipment available, and to extend and interpret the data gathered from a limited number of tests. This procedure has proved both timesaving and reliable.

Proper mounting of the test specimen is most important for the sensitivity curve to have any significance. Whenever possible, the device should be mounted exactly as in the service application. In this way, the only simulation involved is the input acceleration pulse. Unfortunately, however, many of the service vehicles carrying inertia devices are physically too large to be accommodated in the testing machines, and the question arises as to the effect of interposing a substitute elastic system between the source of shock and the component to be tested. This problem of transmission of shock through complex structures has not yet attained the stature of a science, because of the dearth of information on the response of even simple mechanical systems to transients.

In some cases, if the actual mounting structure is too large, an intermediate mounting structure which "sees" the input pulse (in service) and is of suitable size can be selected. This method, of course, depends entirely on the judgment of the individual who decides on the relative rigidities of the structural members.

A simple, and also determinate, method of testing inertia devices is to use a relatively rigid mount which faithfully transmits the input (test) pulse. In this way, whenever the entire service mount or some intermediate mount cannot be tested as a unit, the performance of the mechanism on a determinate mount is ascertained. Although application of this information to the service mounting condition may be difficult, the procedure is much more satisfactory than making indeterminate attempts at simulation of mounting. It may be observed that the usual ordnance application of an inertia switch corresponds to the rigid mount (switch frequency considerably lower than structure frequency), and that many of the cases which do not fit in this category are of a size suitable for full-scale testing of the entire weapon.

After the machines have been selected and the specimen mounted, testing for sensitivity is accomplished by finding the minimum velocity change for actuation of the device. The sensitivity levels for various pulse durations are determined and the inertia sensitivity curve plotted. The procedure is repeated for representative oblique orientations of the test specimen.

Table 2—Comparison of Shock Testers

Salient Features	Conventional Drop Tester	Gravity Sensitive Component Shock Tester
1. Proper orientation of specimen with respect to gravity	No	Yes
2. Shock range	2 to 6000 g 0.25 to 25 fps 0.2 to 40 msec	2 to 50 g 0.25 to 10 fps 2 to 50 msec
3. Tailoring of shock pulses	Yes	Yes
4. Payload for comparable size machine	100 lb	25 lb
5. Operation	Unskilled operator	Skilled operator
6. Test vehicle	No balancing required; vehicle needs no arresting	Balancing required; vehicle requires arresting
7. Cost (for 100 lb payload)	$10,000	$30,000
8. Maintenance	Negligible	Frequent air-gun lubrication
9. Uses	Extensive	Limited to low-acceleration applications
10. Type of machine	Simple	Moderately complex

Test Facilities and Methods

Selecting test equipment suitable for conducting inertia-sensitivity studies is another problem. In the past, conventional free-fall drop testers provided much of the data necessary for these studies. With the development of more sophisticated and higher energy test equipment[3], such as air guns, centrifuges, and square-wave testers, it was possible to extend the range of shock coverage, thereby giving a more complete picture of inertia-device performance. The characteristics of this equipment are summarized in Table 1. Fig. 8 presents an experimentally determined inertia-sensitivity curve plotted from the results of tests run on several of these machines.

New Requirements: Although the full practical ranges of acceleration, the duration of acceleration, and velocity change (with some variation in pulse shape) can be covered by free-fall drop testers, in relating laboratory test data to actual service conditions it has been necessary to neglect the effect of gravity on the inertia devices under study. In the past, accelerations required to actuate most inertia devices were relatively high; thus, the errors in test results were small or negligible. With the development of more sophisticated weapons, inertia devices became considerably more sensitive and it was no longer possible to neglect the effect of gravity.

Refinement of Old Test Methods: Because conventional shock test facilities were designed to operate along one principal axis or plane, it was impractical or extremely difficult to adapt them to gravity-sensitive component testing. Some improvement in the technique of testing these devices, however, was accomplished by counterweighting free-fall drop-tester carriages. For want of a better method, this technique was used in inertia-sensitivity tests for several years. A breakthrough in this type of testing came with the development of the NOL experimental gravity-sensitive component shock tester[4] shown in Fig. 9*a*. Service conditions as well as several simulation techniques are presented schematically in Fig. 9*b*. Also, by way of comparison, some of the typical shock pulses generated with this tester are presented in Fig. 9c. In Table 2 the salient features of the new tester are compared with those of conventional drop testers.

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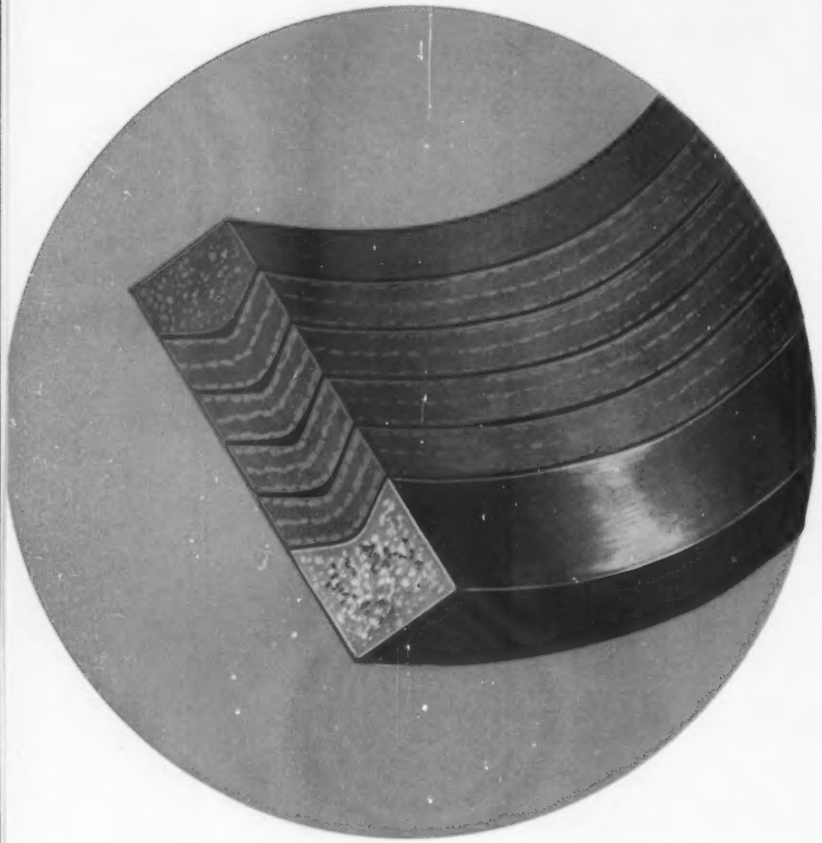
1. M. Kornhauser—*Evaluation of Inertia Sensitivity*, NavOrd Report 3577, November 24, 1953.
2. J. M. Frankland—*Effects of Impact on Simple Elastic Structures*, David Taylor Model Basin Report 481, April, 1942.
3. *Shock Testing Facilities*, Naval Ordnance Laboratory Report 1056 (second revision), March 1, 1956.
4. G. Stathopoulos and V. F. DeVost—*Gravity-Sensitive Component Shock Tester*, NavOrd Report 5779, August 27, 1958.



Recent tests shed new light on the best materials for increasing performance of . . .

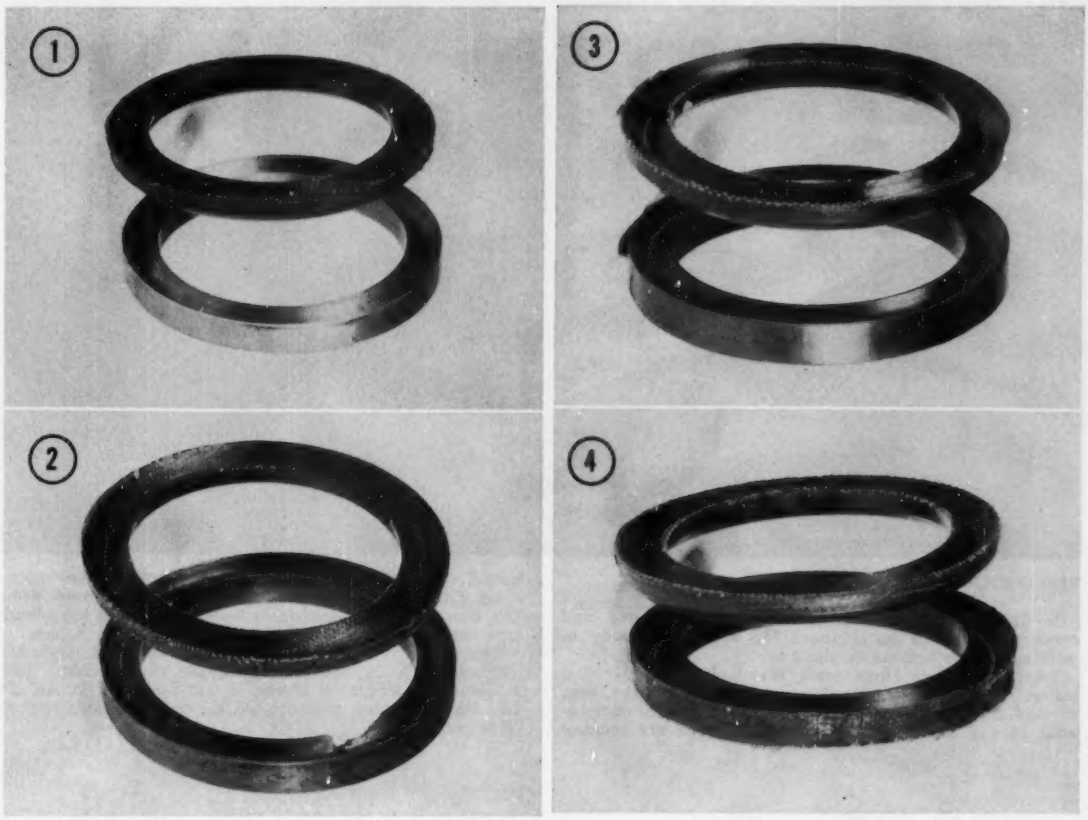
Adapters for V-Ring Packings

J. N. SMITH
Manager
Hydraulics & Transmission Dept.
E. F. Houghton & Co.
Philadelphia, Pa.

OVER-ALL performance of nested V-ring packings depends, to a large extent, on the female adapter. Results obtained from actual V-packing installations, as well as laboratory studies, indicate that the female adapter material and its hardness exert a direct and telling influence on the wear pattern of the entire packing set. Therefore, to get the best performance from a set of V's, the various adapter materials and their characteristics should be carefully analyzed.

Metal Adapters: The growing use of leather and homogeneous V-packings was a prime mover in the expanding use of metal female adapters. The metal, usually bronze, also lasts longer and provides additional bearing area.

Metal adapters do little to prevent extrusion of the V's above 3000 psi. And, above 25,000 psi, bronze adapters frequently develop small cracks at the apex of the V. Softer metals eliminate this tendency to fracture, but permit excessive friction to develop



1 Metal Adapter—
Rigid, low friction, little wear. A poor wear pattern results for the packing, since it does not "breathe" under pressure.

2 Phenolic Adapter—
Softer than metal, does not breathe under pressure. Results are fracture, and a V-packing wear pattern only slightly better than that of metal.

3 Homogeneous Rubber Adapter—
Fairly rigid, but breathes. Wear pattern for the packing is acceptable.

4 Fabric Adapter—
Slightly softer than the homogeneous material. It breathes and helps V-packing exhibit a good wear pattern, but the adapter tends to extrude.

from expansion and binding of the metal.

Leather Adapters: At pressures up to 85,000 psi leather adapters are the best for a set of V-packings. But, they are more expensive and are subject to the limitations imposed by heat and acidity. Under 3000 psi, a fabricated or relatively hard homogeneous adapter does as well as leather, provided clearances are not excessive.

Hard, Homogeneous Rubber Adapters: This type of adapter is quite common for industrial applications. These adapters are molded from synthetic rubber compounds and are used for JIC standard V-packing sizes.

Phenolic Adapters: Phenolic adapters, in "rock-hard" form, are sometimes recommended to obtain bearing area, additional support for the V set, and antiextrusion properties. They are available in machined form, and are molded.

Table 1—Order of Merit for Adapters

Material	—Performance of Set— Friction	Leakage	Wear	—Component Wear— V-Ring	Female Adapter
Bronze	1	2	3	4	1
Phenolic	4	3	4	3	4 (fracture)
Homogeneous	2	1	1	2	2
Fabric	3	1	2	1	3

Rating 1 = best, 2 = next best, etc.

Qualitative Adapter Comparisons: Considerable information upon which design recommendations can be based has been obtained from recent tests performed on one and four V-nests. For purposes of comparing the performance of the V-packings and adapters, numerical ratings were assigned to each type of seat ring in each of its tested functions—"1" the best, "2" the next best, etc. All of the

TEST PROCEDURE—

In the Justice machine, temperature, pressure, and cycling speed can be adjusted for a detailed study of packings under various conditions.

Two sets of packings were installed lip-to-lip on a piston, and pressure was introduced between the sets, so that locked pressure was maintained by an accumulator in the line. The piston was mechanically reciprocated, and friction, leakage, and temperature were measured. Friction and temperature cannot be considered without a similar consideration of leakage, since a high leakage rate produces low friction and temperature values.

The physical conditions of the test included: Cylinder diameter, 2¾ in.; surface finish, 20 rms; medium, light mineral oil; length of stroke, 6 in.; speed of stroke, 24 per minute; spring pressure, 25 lb; and pressure, 1000 to 3000 psi.

phenolic adapters chosen for test were classified in one group, thereby reducing the over-all group to four types of materials. Results obtained under these conditions are shown in Table 1.

All types of phenolic adapters ruptured at about 1000 psi. Machining the adapters to fit the individual cylinder, with a maximum diametral clearance of 0.002 in., can reduce the number of fractures. But, such "tailoring" is far from practical in actual application, especially in the manufacture of cylinders where tolerances on diameters are held to a total variation of 0.015 in. or greater.

The metal female adapter withstands extremely high temperatures. The temperature resistance of the fabric and phenolic adapters depends upon the type of reinforcement being used. The investigations previously described indicate the following temperature limits which should be observed in the selection of adapter materials:

Adapter Material	Temperature Upper Limit (F)
Homogeneous	225
Fabricated cotton	250
Phenolic cotton	250
Fabricated asbestos	300
Phenolic asbestos	275

At elevated temperatures, the phenolic adapters tend to extrude rapidly, especially if pressure is simultaneously increased. This is characteristic of all plastics or resins.

Recommendations: The type of male adapter employed in a V-packing installation has negligible effect on friction, leakage, or wear pattern of the V's. However, the female adapter exerts a direct influence on these variables.

A resilient female adapter will add to the friction generated by the set as the set cycles in the cylinder. But, it will also "breathe" under pressure, with the packings, thereby reducing leakage and bridging the clearances. As a result of clearance reduction, the wear pattern of the V-packings becomes excellent. The female adapter shows signs of slight extrusion.

As the female adapter becomes more rigid, friction generated by the set decreases because the adapter does not breathe. But, the wear pattern, extrusion, and leakage of the V's become more and more severe, while the female adapter itself shows no evidence of extrusion or wear.

None of the sets were tested to destruction, but, from the wear patterns established, it can be estimated that the use of a resilient female adapter almost doubles the life of the V-packings it supports. The tests confirmed the theory that a mechanical packing should be so mounted that the packing can breathe with the actuating pressure.

If a phenolic adapter is to be used as a wear ring, or to obtain increased bearing area, it is preferable to use an adapter of resilient material backed by a phenolic washer or "bull ring" as a separate unit. This method allows the components to function independently.

Nomogram speeds calculation of

Thermal Stresses

F. CAPLAN, Engineer, Kaiser Engineers, Div. of Henry J. Kaiser Co., Oakland, Calif.

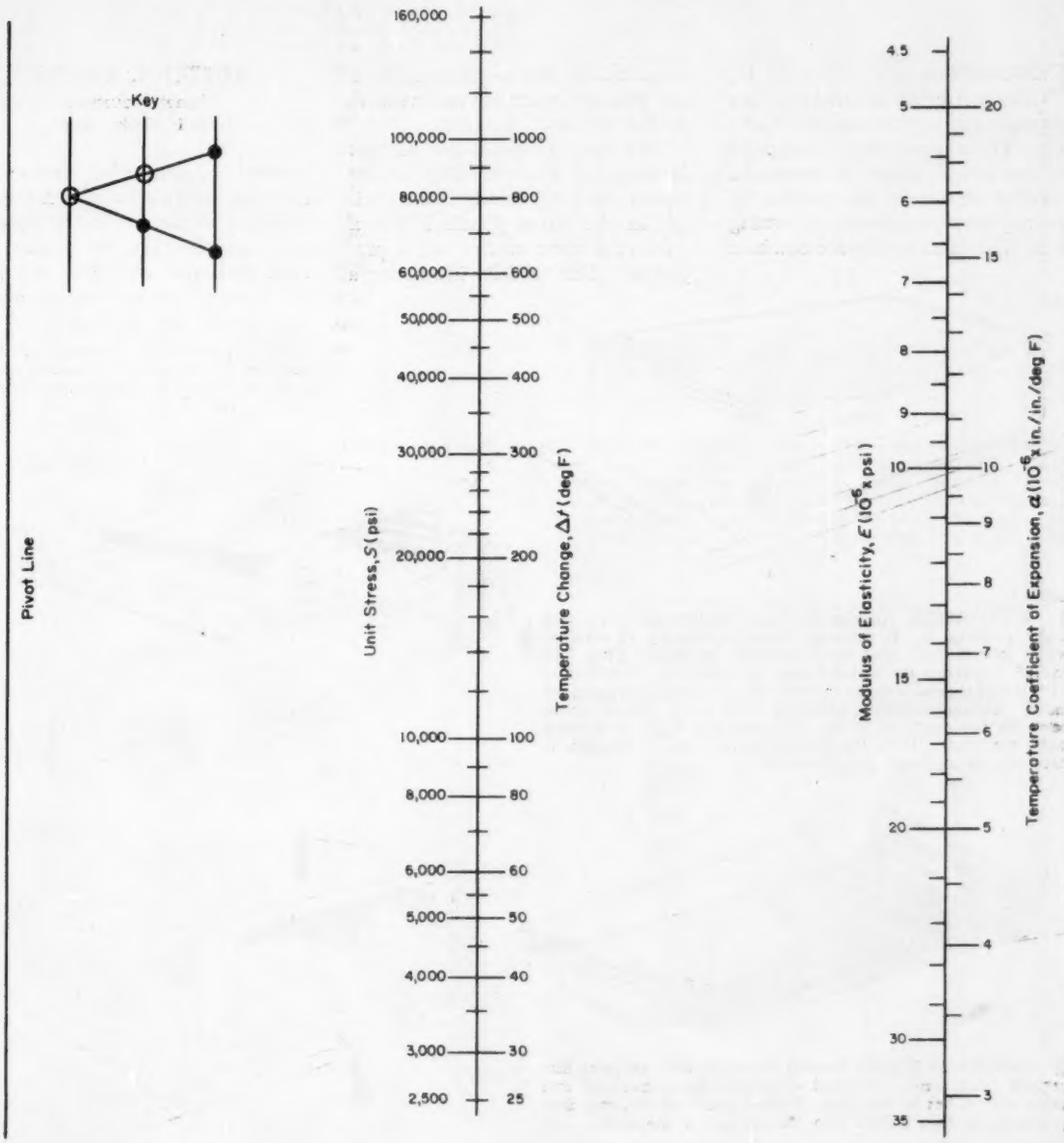
WHEN the temperature of a member with fixed ends is changed, stresses are set up in the member. These stresses, either tensile or compressive, are independent of the member length and are given by:

$$S = E\alpha(\Delta t)$$

where E = modulus of elasticity, psi; α = temperature coefficient of linear expansion, in. per in. per deg F; Δt = temperature change, deg. F.

The nomogram presented here gives a graphical solution of this equation.

EXAMPLE: A steel tie-rod with rigidly fixed ends is heated from 10 F to 110 F. Determine the compressive stress in the member. Draw a line from $E = 30 \times 10^6$ to $\Delta t = 100$ and continue the line to the pivot line. Then draw a line from the pivot line point to $\alpha = 6.5 \times 10^{-6}$ and read the stress, 19,500 psi, on unit stress scale S.



Thermoforming Techniques

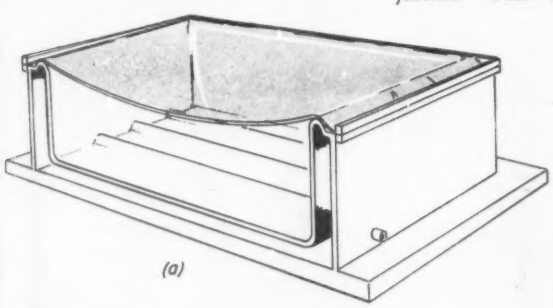
To keep pace with design requirements of plastic products, a number of deep drawing techniques have been developed. Here's how they work.

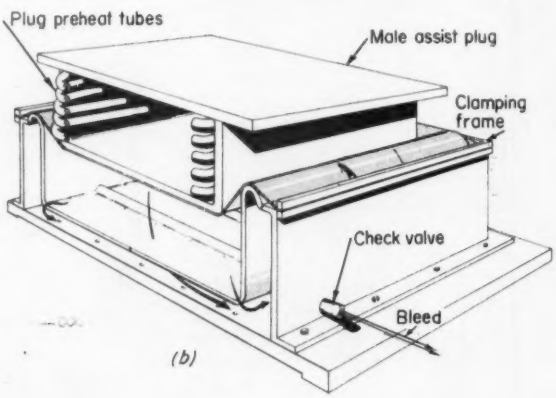
ROBERT E. KOSTUR
Comet Industries
Franklin Park, Illinois

COMMON to new techniques for thermoforming plastics are the operations of predrawing or redrawing. These operations correspond to the several stages in compound forming of metals, but plastics do not require a progression of drawing dies. The same results are obtained by controlled and co-ordinated heat, air pressure, vacuum, and relative motion of mold members.

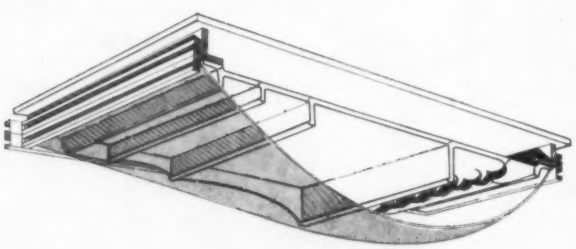
Two basic processes are *vacuum forming* and *drape forming*. In the former, plastic is drawn *into* a cavity. In the latter, plastic is drawn *onto* (the outer surface of) a projection. This article illustrates a number of other thermoforming processes, most of which are combinations of the two basics. In each case, assume that the plastic has been preheated uniformly and that air pressure or mechanical means eject the molded products.

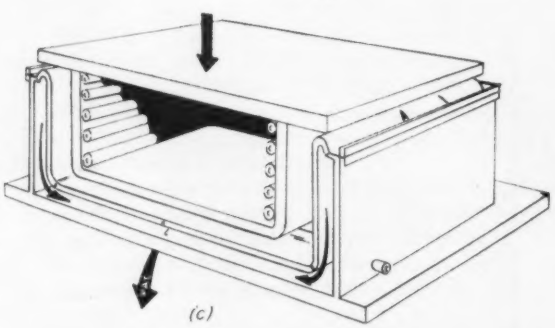
SPE Paper No. 64, "Summary of Thermoforming Techniques," presented at the Sixteenth Technical Conference, Chicago, January, 1960, 5 pp.



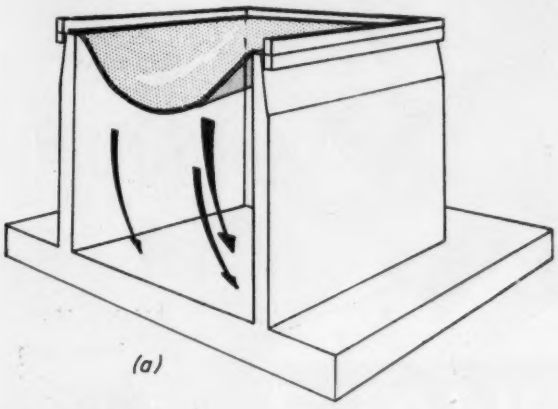


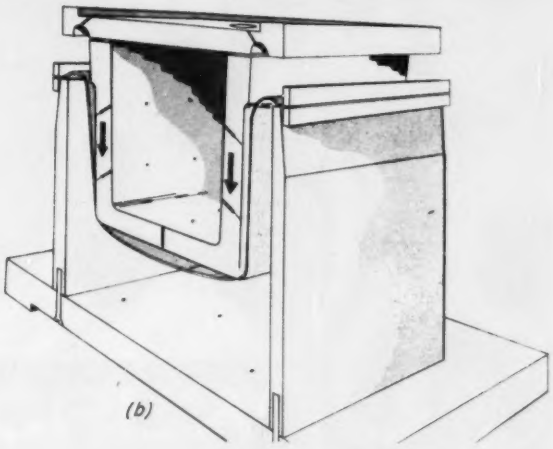
1 PLUG ASSIST forming is a combination of cavity and drape forming, *a*. It prevents excessive thinning of material when formed into deep mold cavities. A heated plug, 120 to 180 F, carries the material into the mold, *b*. Distribution of material depends on the distance that the plug penetrates the mold. Clearance between plug and mold is not critical—about one-fifth the depth of draw. At maximum depth, *c*, vacuum pulls the plastic from the plug onto the cavity. Caution is necessary to minimize plug mark-off.



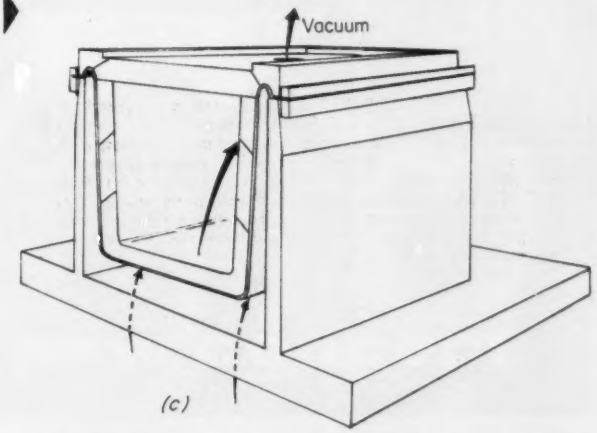


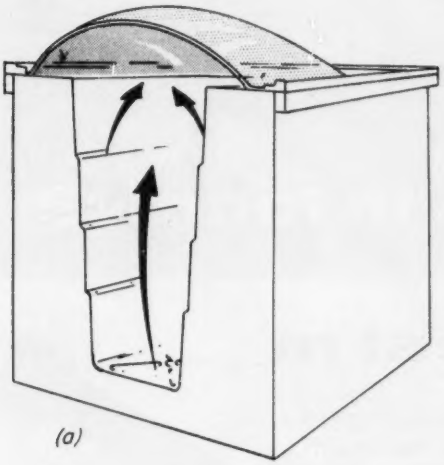
2 INVERTED DRAPE forming is widely used on parts that require plug assist. Inverted drape eliminates mark-off and other defects left by the plug. Heated plastic shown, sags into preshape, is then pulled into all cavities of the mold.



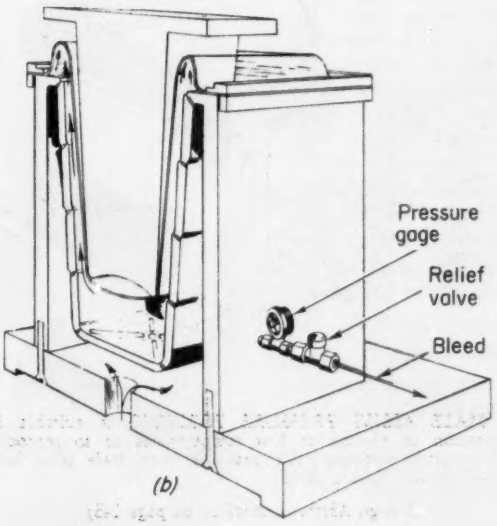


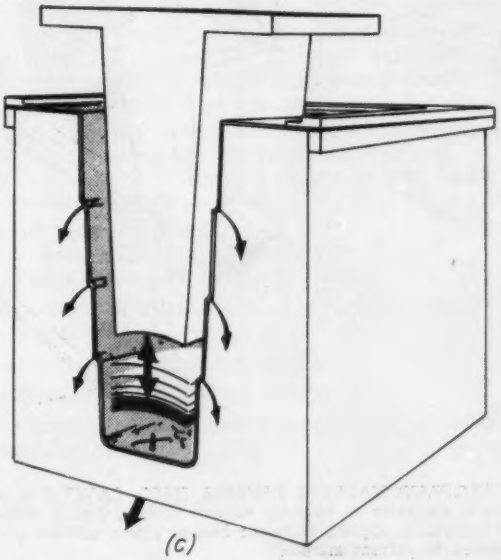
3 VACUUM SNAP-BACK technique functions with minimum blank size and provides uniform material distribution. Uniformity is accomplished by predrawing the plastic into the box with vacuum, *a*. Male mold follows the plastic to maximum depth and seals the box, *b*. Vacuum in the male mold draws plastic to final shape.

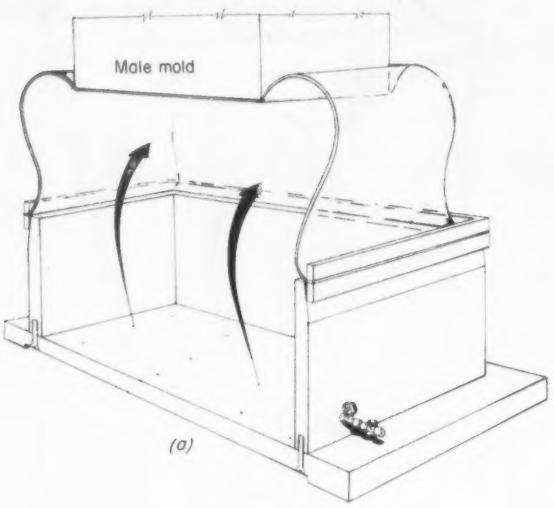


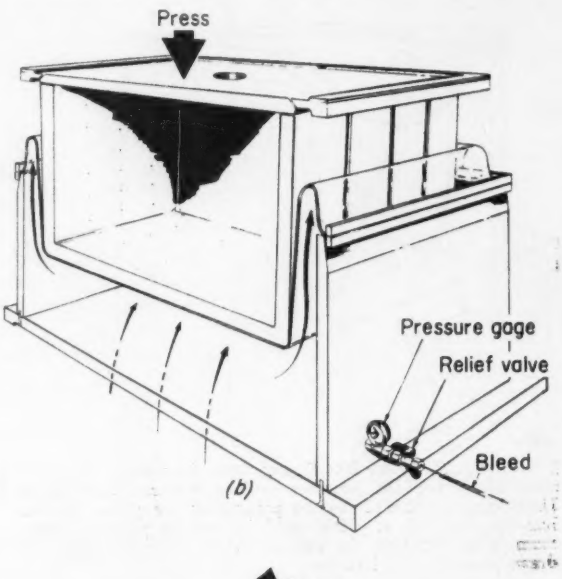


4 BILLOW FORMING begins with preheated plastic blown upward, *a*, by compressed air. Plug enters cavity, *b*, at constant speed. Resultant surge of air pressure distributes plastic around the plug. Air supply is reversed, drawing plastic to the female mold, *c*. In another kind of billow forming, called cushion forming, air blows through the plug in addition to the cavity to support the plastic from two sides.

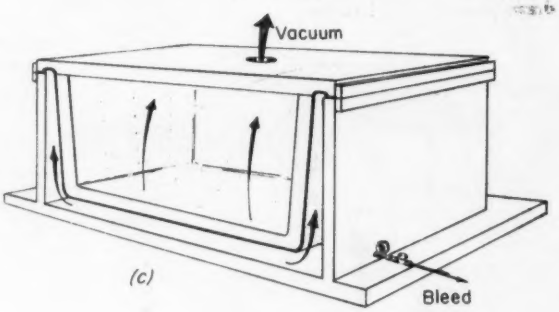


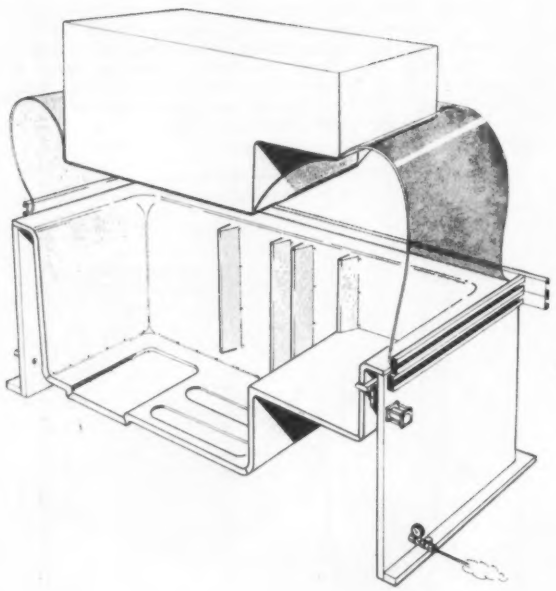




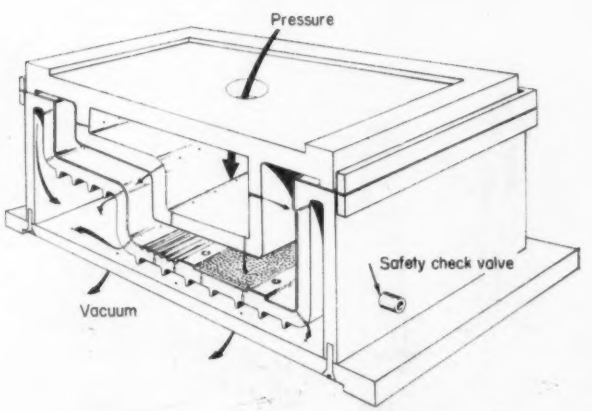


5 BLOW-UP VACUUM REVERSE is used when products must have thin side walls and heavy bottoms. First stage is the same as Fig. 4*a*. When male mold contacts plastics, *a*, *b*, air from within mold is cut off. At end of stroke, *c*, pressure in male mold is reversed to vacuum, and the product rides out with the plug. Blank thickness is calculated as an "area equivalent" ratio with respect to the area to be covered. Expect to get 100 per cent use of center area and 50 per cent of the remaining area.





6 BLOW-UP VACUUM REVERSE INTO CAVITY is essentially the same as blow-up vacuum reverse, Fig. 5, except that vacuum is applied from the bottom platen and the plug is heated to prevent mark-off.



7 MALE ASSIST PRESSURE FORMING is suitable for fabrication of plastics at low temperatures or to reproduce mold surface textures. Air pressure from male plug holds plastic against female mold.

(Design Abstracts continue on page 146)

STANSCREW

Symbol of a new concept

in fastener service

American industry is learning Stanscrew means extra values.

This symbol personifies a trained staff of fastener specialists. Their technical assistance can often help you reduce fastener and assembly costs.

It means extra quick deliveries from complete inventories maintained at three conveniently located plants . . . over 5,000 different types and sizes to assure a broad selection for the great majority of your requirements . . . and, above all else, fasteners of consistently high quality.

Although it first appeared in 1958, the Stanscrew trademark represents a wealth of fastener experience. For it combines the technical skills and specialized facilities of three major manufacturing divisions of Standard Screw Company, each an honored name for more than 80 years. They are:

THE CHICAGO SCREW COMPANY, BELLWOOD, ILLINOIS
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For fasteners, specify Stanscrew. For other needs of home and industry, Standard Screw divisions also produce:

Moen single-handle faucets • *Hartford textile spindles*
Roosa Master fuel injection pumps • *Chicago tappets*

Each division also provides a complete design and manufacturing service for cold headed and screw machine products.

STANDARD SCREW COMPANY
2701 Washington Boulevard • Bellwood, Illinois

Circle 472 on Page 19

electrical

Square-Wave AC Power Source

William A. Geyger, U. S. Naval Ordnance Laboratory

New circuits for magnetic-coupled multivibrators and their use at high ac frequencies, up to about 100,000 cps. These circuits make it possible to adjust ac oscillation frequency, within wide limits, without changing magnitude of output voltage and without impairing output waveform. Adjustment is accomplished by connecting a saturating reactor with rectangular-hysteresis-loop core material in parallel to the load or across the collector terminals. This type of multivibrator is used as a square-wave power supply for magnetic amplifiers, induction motors, gyros, and torque relays.

AIEE Paper No. 60-96 presented at the AIEE Winter General Meeting, New York, January-February, 1960, 12 pp.

Thermoelectric Concepts For Engineers

A. G. Milnes and N. Alfonso, Carnegie Institute of Technology

Thermoelectric concepts in terms of simultaneous equations involving current and heat flows. With the aid of the Onsager theorem of statistical mechanics, it is shown that the thermoelectric effects are reversible and do not contribute to entropy change in a closed system. Well known thermodynamic relationships between the thermoelectric coefficients follow readily.

AIEE Paper No. CP 60-173, presented at the Winter General Meeting, New York, January-February, 1960, 16 pp.

hydraulic

Cavitation in a Mixed-Flow Pump Impeller

G. M. Wood, J. S. Murphy, and J. Farquhar, Pratt & Whitney Aircraft

Effects of cavitation on hydraulic performance of a mixed-flow impeller design which was tested with four, five, and six vanes in a closed water loop. Two idealized flow models for incipient cavitation were derived to illustrate limits of cavitation design. It was found that

both vane blockage and solidity effects are important when designing for optimum cavitation performance. Data show incidence and speed effects and the lip static-pressure profiles in cavitating and noncavitating flow.

ASME Paper No. 60-Hyd-7, presented at the Gas Turbine Power & Hydraulic Conference, Houston, Texas, March, 1960, 12 pp.

Basic Principles of Ground-Cushion Devices

Gabriel D. Boehler, Aerophysics Co.

Analysis of the basic principles which govern the operation of ground-cushion devices currently known as ground-effect machines (GEM's).

Most GEM's can be defined as machines which operate in close proximity to the earth's surface without ever physically touching it because they are always separated from it by a cushion or a layer of air, however thin. As a consequence, propulsion and control of GEM's must be of an aerodynamic nature.

It is proposed to establish six main categories of GEM's from which all other possible configurations could be evolved by combination of the basic types. For each of these six configurations, a critical bibliographical survey is made and some comparative features are pointed out. The over-all picture is one of great complexity because of the large number of parameters involved.

SAE Paper No. 133A, presented at the SAE Annual Meeting, Detroit, January, 1960, 24 pp.

techniques

Reliability Through Component Standardization

H. R. Allers and P. I. Magnani, Military Products Div., IBM.

Standardization of "in-the-house" component part selection with that for "subcontracted" components. Description is given of the problems which precipitated the formation of a component application group and the organization of the specification which now covers subcontract activity. Main provisions are

Circle 475 on Page 19

Fourth Conference on Manufacturing Automation

TO BE HELD AT

Purdue University, Lafayette, Indiana
April 11, 12, and 13, 1960

For production executives, manufacturing engineers, and administrative managers who plan, design, and install automated systems for industry.

As in past conferences, informal discussion groups will be set up where automation authorities will be available to answer specific questions and exchange experiences. Exhibits of automation components and systems have also been arranged.

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AUTOMATION

FEE

Fee for the Third Conference on Manufacturing Automation is $85 which will include the Banquet, the noon Luncheons, and a copy of the Transactions.

LODGING

Rooms are available at the Union Club on the campus at $4 and $6 single, $6 double, and $7 to $9 twin. Room reservations may be made with the Union Club by the form supplied. Accommodations are also available at the Fowler Hotel in Lafayette (city bus to campus) from $3.50. Write direct. For those driving, reservations may be made at the Morris-Bryant Motel, Cedar Crest Motel, or Green Acres Motor Court (2-4 miles north on U. S. 52). For additional information, write K. E. Glancy, Div. of Adult Education, Purdue University, Lafayette, Ind.

CONFERENCE TOPICS AND SPEAKERS

Engineering Costs—Who Pays? (Automation Panel)

BUYERS K. C. BUTTERFIELD, Staff Master Mechanic, Chrysler Corp.
W. W. KUYPER, Manager, Manufacturing Engineering, Large Steam-Turbine Generator Dept., General Electric Co.
R. L. SCHOENBERGER, Manager, Production Engineering Dept., R. R. Donnelley & Sons Co.
W. A. STADTLER, Director of Manufacturing Research, I.B.M. Corp.

SELLERS J. R. BAREFOOT, President, Federal Machine & Welder Co.
LEO GAJDA, Vice President, Snyder Corp.
E. McFERREN, Vice President-Sales, Giddings & Lewis Machine Tool Co.
W. K. STOKES, Vice President-Sales, Alvey Ferguson Co.

Manufacturing Research and Automation
T. R. BUNNELL, Manager of Manufacturing Services, Semiconductor Div., Sylvania Electric Products Inc.

Getting a Grip on Costs and Payoff
K. H. MEYER, Manager, Mfg. Services, Reliance Electric & Engineering Co.

Organizing to Reduce Costs through Automation
C. D. EVANS, Ass't. Manager, Mfg. Research, International Harvester Co.

Process Analysis and Machine Procurement
H. A. LEONE, Manager, Headquarters Mfg. Lab., Westinghouse Electric Corp.

Automating Assembly
C. H. STANDISH, President, Designers for Industry Inc.

Integrating the Packaging Operation
WILLIAM WOOD, President, Processes Research Inc.

Techniques for Parts Handling
R. H. BONNER, Application Engr., Industrial & Machine Tool Operations, Radio Corp. of America

Dispensing Problem Materials in Process
L. E. HARPER, President, Omega Machine Co. Div., B-I-F Industries Inc.

Mechanization for Distribution
E. J. HARDY, Ass't. Supt., Engineering Equipment Development, Western Electric Co.

Temperature Controls
H. G. PAYNE, Manager, Measurement Group Sales Product Div., Foxboro Co.

Using Relay Control Effectively
ZEKE SMITH, Vice President & Tech. Dir., Potter & Brumfield Div., American Machine & Foundry Co.

Doing the Job with Photoelectrics
J. J. LAREW, Product Engr., Specialty Control Dept., General Electric Co.

LUNCHEON AND BANQUET TOPICS AND SPEAKERS

Pioneering in Automation
W. C. LEONE, Vice Pres. & Gen'l. Mgr., Electronics Div., Rheem Mfg. Co.

You and the MEC
F. I. ELLIN, Chief Production Engr., Ohmite Mfg. Co.

A Look Into Tomorrow
JOSEPH HARRINGTON JR., Head, Mechanical Engineering Section, Arthur D. Little Inc.

Don't Give Up
ROBERT MOORE, President, Moore Equipment Co.

The Inevitability of Automation
H. A. STRICKLAND JR., Vice President & Gen'l. Mgr., Industrial Electronics Div., General Electric Co.

Mail to: AUTOMATION CONFERENCE, Comptroller's Office (Conferences), Purdue University.

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Please reserve in the Union Club the accommodations checked:

Nights: April 11 ☐ April 12 ☐ April 13 ☐

Single Bed—Bath ☐ Twin Beds—Bath ☐

If necessary, will share twin-bed with another member ☐

Room will be shared by _____

Please send confirmation:

Name _____

Company _____

Address _____

CONFERENCE REGISTRATION

The following persons plan to attend the AUTOMATION CONFERENCE, April 11, 12, and 13, 1960 (name and title, please):

Name _____

Title _____

Name _____

Title _____

$_____ is enclosed for the registrations checked at $85 each. (Make checks payable to Purdue University.)

☐ Fees will be paid at registration time.

Name _____

Company _____

Address _____

selection and application of part types, parts list submissions, and environmental and life test requirements.

IRE paper presented at the 1960 Winter Convention on Military Electronics, Los Angeles, February, 1960.

The General-Purpose Electronic Analog Computer

E. A. Clarke
Humble Oil & Refining Co.

A state-of-the-art presentation on the general-purpose electronic analog computer.

Analog computation has been slower to develop than digital because the technique is different. Instead of working stepwise from one calculation to the next, all the mathematical relationships are programmed initially and the results obtained almost immediately. It is a simultaneous solution of each portion of a calculation.

The general-purpose analog computer can be considered as a large collection of "black boxes," each capable of carrying out a specific mathematical operation, such as: Algebraic summation; multiplication and division; integration and differentiation; generation of trigonometric functions; generation of arbitrary functions; logic; and decision-making. Recent developments in analog computer techniques and design will permit the combination of sequential and simultaneous calculations.

AIEE Paper No. CP 60-56 presented at the AIEE Winter General Meeting, New York, January-February, 1960, 7 pp.

TO OBTAIN COPIES of papers or articles abstracted here, write directly to the following organizations:

AIEE—American Institute of Electrical Engineers, 33 West 39th St., New York 18, N. Y., papers 50 cents to members, one dollar to nonmembers.

ASME—American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y., papers 40 cents to members, 80 cents to nonmembers.

IRE—The Institute of Radio Engineers, 1 East 79th St., New York 21, N. Y.

SAE—Society of Automotive Engineers, Inc., 485 Lexington Ave., New York 17, N. Y., papers 50 cents to members, 75 cents to nonmembers.

SPE—Society of Plastic Engineers, Inc., 65 Prospect St., Stamford, Conn., papers 25 cents to members, 40 cents to nonmembers.

Circle 477 on Page 19

Helpful Literature
for Design Engineers

For copies of any literature listed, circle Item Number on Yellow Card—page 19

Mechanical Shaft Seals

Two new designs in water-pump shaft seals, types WPR and WPS, are described and illustrated in Form 100. Folder shows cutaway views of the seals, and includes prints and data covering space requirements and typical applications, together with a brief explanation of the sealing principle behind rotary seals for rotating shafts and normal components of the seals. 4 pages. Muskegon Piston Ring Co., Rotary Seal Div., Sparta, Mich.

Circle 601 on Page 19

Bolt Fatigue Life

Fatigue life control of threaded fasteners is discussed in Design Manual 5930. It illustrates the Equa-Stress modified UNF-3 thread form which, when installed in a new series of nuts, will at least double fatigue endurance of a standard high-tensile bolt. Manual includes findings related to the basic nature and causes of fastener fatigue, six detailed drawings of new Double-Durability self-locking nuts, and applicable fatigue performance test results. 32 pages. Elastic Stop Nut Corp. of America, Dept. D/D, 2330 Vauxhall Rd., Union, N. J.

Circle 602 on Page 19

Miniature Motor-Generator

RBG-2407 miniature motor-generator unit consists of a low-inertia control motor and a 10 v per 1000 rpm ac drag-cup rate generator. It is designed for precision instrument applications. Bulletin MO-3.14 includes motor speed-torque and speed-voltage curves, complete dimensions, and electrical characteristics of the rate generator and combined unit. 2 pages. National Pneumatic Co. Inc., Holtzer-Cabot Motor Div., 125 Amory St., Boston 19, Mass.

Circle 603 on Page 19

Screw Conveyors and Feeders

Comprehensive Book 2989 illustrates over 20 different types of screws, 14 types of troughs, and 4 types of covers, 5 types of discharge openings, and 2 types of feeders. Book shows uses of screw conveyors for various applications. It contains an extensive list of materials for which conveyors can be used. 76 pages. Link-Belt Co., Dept. PR, Prudential Plaza, Chicago 1, Ill.

Circle 604 on Page 19

Fabricated Silicone Rubber

Bulletin HTM on custom-engineered, fabricated silicone rubber describes engineered seals for the aircraft, electronic, and appliance industries, precision-molded parts, extruded parts, and sheet and die cuts. Using the manual, engineer can select and specify the correct silicone-rubber part to meet typical application problems. Special-purpose compounds to meet specific requirements are also listed. 6 pages. Haveg Industries Inc., Taunton Div., 336 Weir St., Taunton, Mass.

Circle 605 on Page 19

Vacuum Induction Melting

Complex process which produces many alloys for aircraft and missiles is described in profusely illustrated booklet titled "Superalloys by Vacuum Induction Melting." In addition, brochure discusses present and future applications of superalloys. Property charts show characteristics of alloys produced by the vacuum induction process as compared to conventional high-temperature alloys. 36 pages. Kelsey-Hayes Co., Metals Div., Dept. 17, New Hartford, N. Y.

Circle 606 on Page 19

Coaxial Connectors

Catalog of microminiature, snap-locking coaxial connectors is now available. Complete details of the connectors are presented, including electrical, mechanical, and environmental specifications and outline drawings. Wide variety of plugs, receptacles, caps, and adapters is shown, in 50, 75, and 95-ohm impedances. Friction-held, push-on connectors for rack and panel installations, miniature coaxial cable and accessories, and separate price list complete the catalog. 8 pages. Electro-Physics Laboratories, Technical Information Service, 2065 Huntington Drive, San Marino, Calif.

Circle 607 on Page 19

Cylindrical Roller Bearings

Three series of cylindrical roller bearings, available in five variations, are presented in Bulletin 114. Information on bearing dimensions and load capacities is provided for each series. 12 pages. Hoover Ball & Bearing Co., 5400 S. State Rd., Ann Arbor, Mich.

Circle 608 on Page 19

Industrial Laminates

Textolite industrial laminated plastic sheets, tubes, and rods are described in Catalog L-CDL-494. Publication lists applications, special features, detailed characteristics, and sizes available in over 50 grades. Included are phenolics, silicones, melamines, and epoxies with filler bases of paper, nylon, cotton, asbestos, and glass fabric. Also shown are features and properties of copper-clad laminates for printed circuits. 16 pages. General Electric Co., Laminated Products Dept., Coshocton, Ohio.

Circle 609 on Page 19

Circuit Breaker

Bulletin B-07 describes Series 500 electromagnetic, hermetically sealed circuit breaker. Inverse time-delay mechanism provides a trip level which is unaffected by ambient or operating temperature. Discussed are available ratings, time delays, trip level, rated current, frequency ratings, possible combinations, and release-coil resistances. Outline dimensions for the series circuit, shunt, and relay types are provided, and typical time-delay curve is shown. 4 pages. Airpax Electronics Inc., Cambridge Div., Cambridge, Md.

Circle 610 on Page 19

Fluid-Power Equipment

Two-color bulletin contains information on products of both the Miller Fluid Power and Tru-Seal divisions of the Flick-Reedy Corp. Designated Bulletin P2547P, it covers air cylinders, hydraulic cylinders, nonsag piston rods, high-speed cushions, adjustable-stroke cylinders, air-hydraulic boosters, air-oil circuits, and Tru-Seal pipe-thread fittings. Simplified mounting and dimensional data and thrust charts permit quick selection of bore sizes and determination of mounting dimensions. 24 pages. Flick-Reedy Corp., York and Thorndale Roads, Bensenville, Ill.

Circle 611 on Page 19

Geared Motor

Gear-O-Matic instant-reversing motor is controlled by built-in adjustable limit switches. Form P86029 presents special features, applications, and sizes available. 4 pages. Franklin Electric Co. Inc., Bluffton, Ind.

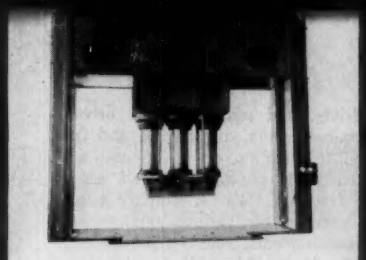
Circle 612 on Page 19

Blowers and Components

Blower assemblies, blower wheels, and parts are fully described in new booklet. Series A and 2-A blower assemblies, Budget blower units, and Econopak units are listed. Electro-Wheel and Direct-Drive blowers are also outlined, as are parts such as pulleys, bearing brackets, bearings, and pillow blocks. Two pages are devoted to various types of wheels available. 12 pages. Lau Blower Co., 2027 Home Ave., Dayton 7, Ohio.

Circle 613 on Page 19

Circle 478 on Page 19→



You can depend on the uniform structure and properties of Meehanite nodular whether the casting weighs ½ ounce as pictured below or many hundreds of pounds. Photograph above shows a 1500 ton Hydraulic press with Meehanite rams.

in nodular iron . .

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Meehanite foundries have the "know-how" and experience

There is nothing new about nodular or ductile cast iron, but the problem is that not every foundry has the metallurgical know-how and facilities to produce castings that live up to published claims.

When you purchase nodular iron from a Meehanite foundry you can always be sure of getting dependable castings that possess the desired engineering advantages — *high strength, ductility, toughness.*

The consistent, high quality of Meehanite castings is achieved by a "proven" manufacturing procedure used by Meehanite foundries throughout the world. Meehanite foundries have over a quarter of a century of experience in the manipulation and use of the essential processing materials needed to convert the graphite in cast iron from the flake form into the nodular.

Put this experience to work for you. Avoid the risk of costly defects. Seven different "S" types of Meehanite nodular are available and there is a nearby Meehanite foundry ready to serve your needs.

For more facts about Meehanite Nodular Iron write for your FREE copy of our new bulletin No. 47. Write today to Meehanite Metal Corp., 714 North Ave., New Rochelle, N.Y.

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The American Laundry Machinery Co., Rochester, N. Y.
Atlas Foundry Co., Detroit, Mich.
Banner Iron Works, St. Louis, Mo.
Barnett Foundry & Machine Co., Irvington, N. J.
Casting Service Corp., LaPorte, Indiana and Bridgman, Michigan
Centrifugally Cast Products Div., The Shenango Furnace Co., Dover, Ohio
Compton Foundry, Compton, Calif.
The Cooper-Bessemer Corp., Mt. Vernon, Ohio and Grove City, Pa.
Crawford & Doherty Foundry Co., Portland, Ore.
Dayton Casting Co., Dayton, Ohio
Empire Foundry Co., Tulsa, Okla. and Bonham, Texas
Florence Pipe Foundry & Machine Co., Florence, N. J.
Fulton Foundry & Machines Co., Inc., Cleveland, Ohio
General Foundry & Mfg., Flint, Mich.
Georgia Iron Works, Augusta, Ga.
Greenlee Foundries, Inc., Chicago, Ill.
Hamilton Foundry Inc., Hamilton, Ohio
Johnstone Foundries, Inc., Grove City, Pa.
Kanawha Manufacturing Co., Charleston, W. Va.
Kennedy Van Saun Mfg. & Eng. Corp., Danville, Pa.
Lincoln Foundry Corp., Los Angeles, Calif.
Oil City Iron Works, Corsicana, Texas
Palmyra Foundry Co., Inc., Palmyra, N. J.
The Henry Perkins Co., Bridgewater, Mass.
Pohlman Foundry Co., Inc., Buffalo, N. Y.
Rosedale Foundry & Machine Co., Pittsburgh, Pa.
Ross-Meehan Foundries, Chattanooga, Tenn.
Sonith Foundries of FMC, Indianapolis, Ind.
Standard Foundry Co., Worcester, Mass.
The Stearns-Roger Mfg. Co., Denver, Colo.
Vulcan Foundry Co., Oakland, Calif.
Washington Iron Works, Seattle, Wash.
Dorr-Oliver-Long, Ltd., Orillia, Ontario
Hartley Foundry Div., London Concrete Machinery Co., Ltd., Brantford, Ontario
Otis Elevator Co., Ltd., Hamilton, Ontario

MEEHANITE METAL CORPORATION, NEW ROCHELLE, NEW YORK

Transformers

Over 750 transformers for industrial, communications, and radio and television applications are listed in Catalog S-105. Complete electrical and physical specifications are shown for all units listed, and new indexing system facilitates locating the required transformer. Other aids include an output transformer chart for matching output tubes to transformers, exact replacement listings of flyback transformers and yokes, and illustrations and descriptions of all transformer types. 36 pages. Chicago Standard Transformer Corp., 3501 Addison St., Chicago 18, Ill.

Circle 614 on Page 19

Wiper-Scraper Seal

SC seal incorporates in a single unit both a wiper and a scraper to provide protection for packings on reciprocating shafts and hydraulic cylinder rods. Seal is described in Bulletin SC-100 which includes sizes, applications, and design information. 4 pages. Chicago Rawhide Mfg. Co., Oil Seal Div., 1301 Elston Ave., Chicago 22, Ill.

Circle 615 on Page 19

Adhesives, Laminates, Putties

Condensed catalog describes complete line of adhesives, laminating materials, putties, and sandwich core material. Feature of the catalog is a temperature chart that indicates upper and lower service limits for each adhesive and laminating material in the line. 6 pages. Narmco Resins & Coatings Co., 600 Victoria St., Costa Mesa, Calif.

Circle 616 on Page 19

Temperature-Sensing Elements

Information on wire, general, aircraft-type, and special-purpose thermocouples is provided in new catalog, which also includes a section on thermocouple accessories. Last section contains complete reference information for the design, identification, and application of thermocouples. Temptron Inc., 7030 Darby Ave., Reseda, Calif.

Circle 617 on Page 19

Pneumatically Actuated Valves

Bulletin HB-7 gives construction details, operating characteristics, and specifications of the Series HB Saunders valves. Included is a section on valve sizing and flow coefficients which aid in the proper selection of Saunders valves. Complete line of valve actuators for either on-off or throttling control applications is presented. 8 pages. Conoflow Corp., 2100 Arch St., Philadelphia 3, Pa.

Circle 618 on Page 19

Stainless-Steel Analyses

Revised Data Chart, Sec. A, No. 1, provides analyses specifications for 58 different types of stainless steel. It covers all 40 standard AISI grades plus 18 specials, including precipitation-hardening grades 17-4, 17-7, and 15-7 MO. Nearest corresponding SAE and AMS designations are cross-indexed with AISI grades. Tabbed 8½ x 11-in. chart is printed on durable card stock. Peter A. Frasse & Co. Inc., 17 Grand St., New York 13, N. Y.

Circle 619 on Page 19

Miniature DC Motors

Type VS precision miniature, permanent-magnet dc motors are 7/16-in. thick by ⅞ by 1⅞ in., and develop 0.1 oz-in. of continuous-duty torque. Bulletin 121 lists features, dimensions, armature selection, and performance characteristics. 2 pages. Globe Industries Inc., 1784 Stanley Ave., Dayton 4, Ohio.

Circle 620 on Page 19

Dry-Film Lubricant

Basic principles of the molybdenum-disulphide-base lubricant are explained in new brochure. No expensive surface pretreatment is necessary prior to applying Poxylube bonded dry-film lubricant. Questions and answers on the use and applications of the lubricant are included. 4 pages. Poly Chem Inc., 541 S. Webster Ave., Indianapolis 19, Ind.

Circle 621 on Page 19

Controlled-Speed Systems

Form F1963, colorfully illustrated with schematic and realistic drawings as well as application photographs, explains the Varidyne ac controlled-speed system principle. Advantages of the system are pointed out, and various applications are presented. 8 pages. U. S. Electrical Motors Inc., Box 2058, Terminal Annex, Los Angeles 54, Calif.

Circle 622 on Page 19

Rotary Switches

Catalog 399 covers 124 types and sizes of low-power rotary switches, both shorting and nonshorting, which can be supplied fully assembled or in subassemblies. Catalog includes complete prices and specifications. 4 pages. Oak Mfg. Co., 1260 N. Clybourn Ave., Chicago 10, Ill.

Circle 623 on Page 19

Steel Tubing

Both seamless and electric-welded steel tubing are described in Catalog CS-60. Carbon and alloy-steel grades of seamless tubing are covered in mechanical, pressure, aircraft mechanical, and airframe categories. Carbon-steel grades of electric-welded tubing are reviewed in mechanical and pressure categories. Another section covers fabrication and forging of steel tubing into finished or semifinished tubular parts and components. 8 pages. Copperweld Steel Co., Ohio Seamless Tube Div., Shelby, Ohio.

Circle 624 on Page 19

Speed Reducers

Bulletin A692 describes modern methods of speed reduction with compact, shaft-mounted units in a wide range of sizes and horsepowers. In addition to an expanded line of Torque-Arm speed reducers for mounting on shafts of driven machines, bulletin also presents reducers for flange mounting, vertical shafts, right-angle drives, and screw-conveyor drives. Construction details, dimensions, and installation information are given and are illustrated with photographs and engineering drawings. Tables simplify selection of reducers for various applications, power requirements, and output speeds. 64 pages. Dodge Mfg. Co., Mishawaka, Ind.

Circle 625 on Page 19

Motors and Relays

Typical specifications on ac and dc fractional-horsepower motors, tachometer generators, and ultrasensitive relays are provided in File F-9765. Rated horsepower, dimensions, special features, and typical applications are listed. Available in a variety of voltage ranges, styles, and specifications, motors meet airborne, commercial, and industrial applications. 4 pages. Barber-Colman Co., Rockford, Ill.

Circle 626 on Page 19

Self-Locking Fasteners

Complete specifications and application information on Banc-Lok self-locking inserts and tapped holes are presented in new catalog. Cross-section application drawings describe features of each and advantages in plastics, sheet metal, and composition materials. Easy-to-use charts detail thread and hole sizes and grip lengths. 8 pages. Boots Corp., Newtown Turnpike, Norwalk, Conn.

Circle 627 on Page 19

Plastic Knobs and Handles

Two-color catalog provides complete information on 49 stock designs of ball, oval, and tapered knobs, tapered handles, push-pull and lid knobs, knurled and fluted handwheels and knobs, thumb screws and terminal nuts, and pointer and instrument knobs. Optional design variations and special materials and colors are also covered. 8 pages. Dimco-Gray Co., 207 E. Sixth St., Dayton 2, Ohio.

Circle 628 on Page 19

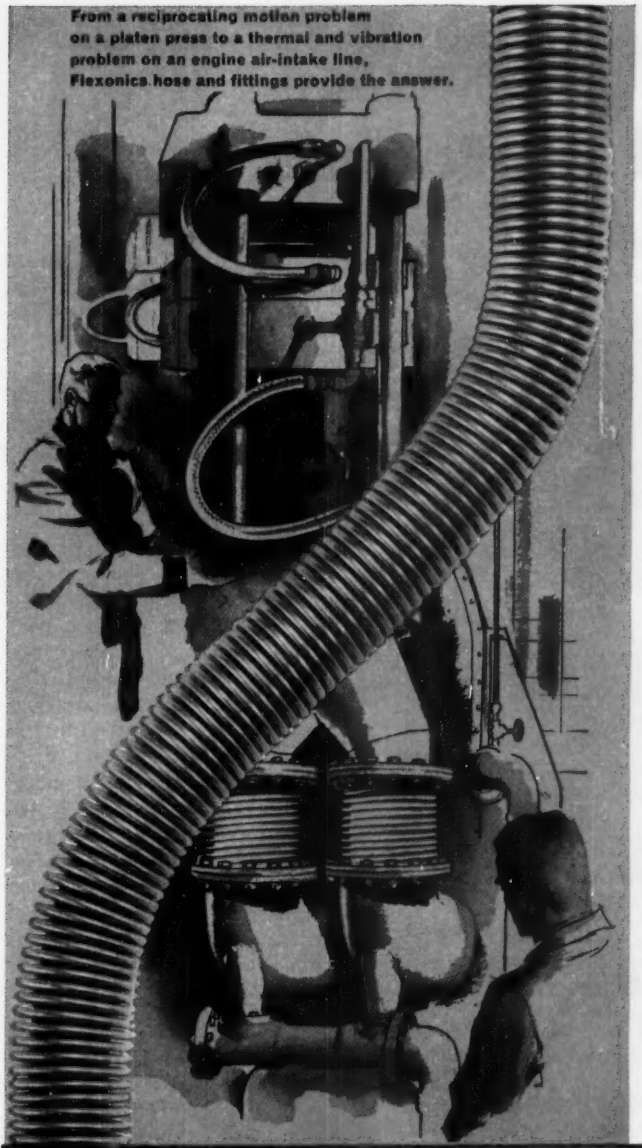
Graphite Properties

Three types of graphite are described in Engineering Bulletin G12 titled "Graphite, Its Properties and Uses." Booklet outlines in detail the principal properties, characteristics, and old and new applications of natural amorphous cryptocrystalline graphite, an unctuous, odorless, tasteless, nontoxic, and easily pulverized material. 8 pages. United States Graphite Co., Sakinaw, Mich.

Circle 629 on Page 19

Electronic Connectors

Condensed Catalog 60 features standard lines of electronic connectors, including basic engineering application data on electronic connector types such as printed-circuit, MS, rack and panel, triaxial, glass seal, and receptacle and cable assemblies. One page lists special connectors engineered and manufactured for specific applications. 16 pages. Request on company letterhead from Burndy Corp., H. H. Buggie Div., 726 Stanton St., Toledo, Ohio.



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YOUR DESIGN REQUIREMENTS for metal hose are greatly simplified by the unparalleled Flexonics experience. The most challenging problems are often solved by Flexonics broad standard line of hose and fittings. It's simply a matter of time and talent! Flexonics has been in the business longer, and has the most talented product engineers, metallurgists and application engineers in the business. The result is rapid and right answers to any design application of metal hose.

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PIPING MISALIGNMENT


VIBRATION & SHOCK


THERMAL EXPANSION & CONTRACTION


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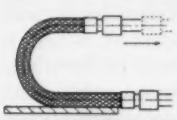
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IH-365

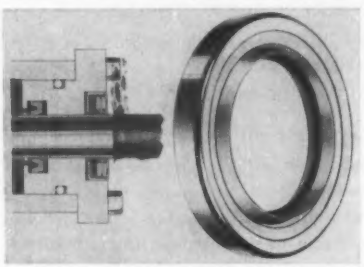
New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Rod-Wiper Seal

incorporates scraper for added packing protection

SC Wiper Scraper seal incorporates both a rod wiper and a rod scraper within a single unit. It provides effective, low-cost protection for packings on reciprocating shafts and hydraulic cylinders exposed to heavy dirt conditions. Seal consists of a thin brass scraper ring in tandem with a pliable synthetic-rubber wiping member, both firmly clamped within a compact steel shell. OD of scraper ring has sufficient play within outer shell to permit realignment and tolerance of any off-center conditions of rod. Seal is available in sizes for shafts from ½ to 6 in. **Oil Seal Div., Chicago Rawhide Mfg. Co.**, 1301 Elston Ave., Chicago 22, Ill.

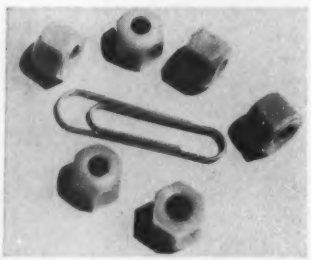


Circle 630 on Page 19

Acorn Lock Nuts

of pigmented plastic

Available for light-duty applications, open-end acorn lock nuts of Delrin provide corrosion resistance and reusable locking action. Prevailing-torque nuts offer excellent strength, rigidity, dimensional stability, and resistance to water and organics. Nontoxic and odorless, material is light in weight, abrasion resistant, and smooth to the touch. No. 10 and ¼-in. sizes are available. Since nuts form own threads



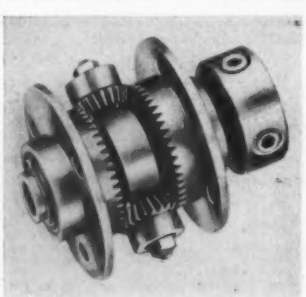
as they are assembled, No. 10 size fits 10-24 and 10-32 threads, and ¼-in. size fits ¼-20 and ¼-28 threads. Colors available are metallic gray, metallic gold, and natural (off-white). Nuts have holding strength of 500-600 lb under straight tension for No. 10 size and 600-700 lb for ¼-in. size. **Russell, Burdsall & Ward Bolt & Nut Co., Dept. DN**, 104 Midland Ave., Port Chester, N. Y.

Circle 631 on Page 19

Miniature Differentials

in ⅛ and 3/16 in. bore sizes have minimum backlash

Miniature, flange-type, hollow-shaft differentials eliminate cost of making a two-piece casting. Shaft slides into position, and clamp-lock device holds shaft in place without pins. Rapid end-gear change is accomplished by removal of three screws. Backlash is held to minimum. Precision differentials, of corrosion-resistant steel, meet applicable military specifications. They are available in ⅛ and 3/16-in. bore sizes. **Superite Instrument Corp.**, 7 Mayflower Place, Floral Park, N. Y.

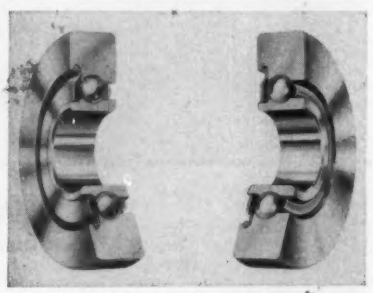


Circle 632 on Page 19

Instrument Bearings

have high OD-width ratio

Designed for use in synchros, gear trains, potentiometers, servos, and small motors, thin-width precision-instrument bearings feature a high OD-width ratio, and are made to ABEC Class-7 tolerances. Bearings are available in nine sizes with ODs from 0.2750 to 0.5000 in. and bores from 0.0937 to 0.1875 in. Standard material for balls and rings is 440 C stainless steel. Open, single, and double-shielded types are included. Narrow width of bearings saves space, making possible the use of longer stators and rotors in synchros and small motors, increasing power without adding to over-all length or diameter of unit. **Miniature Precision Bearings Inc.**, Precision Park, Keene, N. H.



Circle 633 on Page 19

Miniature Electric Heaters

are furnished in 2, 5, and 10-w ratings

Miniature electric heaters are only ¾-in. diam and 0.15-in. thick, and have a center hole for No. 2 screw mounting to any flat surface. Six-inch lead wires, No. 28 Teflon in-

PRODUCT-DESIGN BRIEFS FROM DUREZ

- **Something extra in molding compounds**
- **Fire-retardant structural plastic**
- **News notes for designers**

Upgrading a product

Good • Plenty of distributor caps are molded of Durez general-purpose phenolic. When cost is a prime factor, general-purpose does the job and does it well.

Best • However, if you're shooting for something extra in a distributor cap (or in almost any electrical part), take a look at *Durez 2271*. This is an electrical-grade phenolic. A ⅛" test disk of it withstands 12 kv at 180° F in air for an hour or more without puncturing. The cost of this extra performance is low: weighing less than comparable electrical-grade materials, *2271* gives you more pieces per pound.

Good • You'd be right in choosing *Durez 791 Black* for a piece like this telephone handset. You'd be able to count on low molding cost because of *791's* fast cure. You'd get the required physicals in good balance. And the price of this wood-flour-filled material is low.

Best • Then why do telephone men favor a different material, *Durez 17225*, for handsets? Because this wood-flour-and-flock-filled material provides even higher resistance to impact fractures. The rich black finish presents an unyielding front to moisture and body acids. Bonus: a part that *more* than meets the specs—for fractions of a penny per piece.

We could go on and on giving you case histories like these. Have you looked into the extras you can build into a product—at next-to-invisible cost—with Durez molding materials? To get a better idea of what these compounds can do for you, send for our illustrated 8-page Bulletin D400 listing properties, uses, advantages.

CONSOLITE (CONSOLIDATED GENERAL PRODUCTS, INC.)

Safer skylight

Here's a plastic skylight that retards fire.

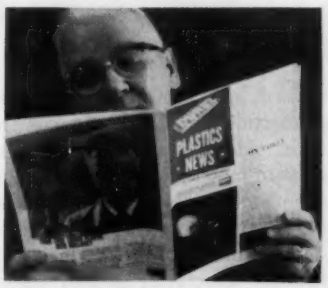
It's made for use in hazardous locations or wherever building codes are exceptionally strict.

The material is fibrous-glass-reinforced Hetron®. It will ignite only under direct hot flame, and snuffs out as soon as the flame source is removed.

Weighing only half a pound per square foot, the skylight material will support a uniform load of 150 pounds per square foot. It is thermally stable from −65° to 200° F, and has great strength and shatter resistance even at subzero temperatures.

Its thermal conductivity is only ⅓ that of glass, yet it can transmit ⅘ as much light as glass without glare. It delivers greater insulating effect than other skylight materials, at lower cost.

Could any of these attributes help *you* design a better product? Hetron® is hard at work already in radomes, chemical ducts, blowers, boat hulls, housings, fume hoods, window panels, canopies. Data on self-extinguishing Hetron resins is yours for the asking.



On keeping abreast

How can a man keep up with all that's new in thermosetting plastics?

Well, it isn't easy. But we can help. We mail out every 60 days a bulletin, *Durez Plastics News*. You can read it in 10 minutes. It gives a bird's-eye view of what's new in the use of Durez plastics. Every item is *news*—hot off the presses of leading molders the country over, whom we visit regularly.

To get this bimonthly packet of ideas and information, just check the coupon.

For more information on Durez materials mentioned above, check here:

- ☐ Phenolic molding compounds (8-page Bulletin D400).
- ☐ Hetron fire-retardant polyester resin (data file).
- ☐ *Durez Plastics News* (mailed bimonthly).

Check, clip, and mail to us with your name, title, company address.
(When requesting samples, please use business letterhead.)

DUREZ PLASTICS DIVISION
503-2 WALCK ROAD, NORTH TONAWANDA, N. Y.

HOOKER CHEMICAL CORPORATION

HOOKER CHEMICALS PLASTICS

Circle 480 on Page 19

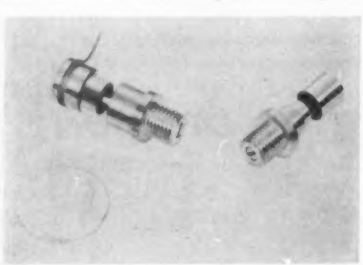
sulated, are provided for electrical connections. Leads emerge from upper side of heater through special glass-to-metal seals. Heaters are completely enclosed in a metal case, flat on the under side for maximum heat transfer to the surface being heated. Operating at 115 volts ac or dc, wattage ratings of 2, 5, or 10 w are standard in ¾-in. diam size. Heater internal temperatures to 500 F are permissible. **Minco Products Inc.**, 740 Washington Ave. N., Minneapolis 1, Minn.

Circle 634 on Page 19

Trimmer Capacitor

miniature unit permits precise, positive adjustment

Miniaturized trimmer capacitor provides high degree of control precision. Nonrotating piston fitted into a glass cylinder with mirror-finished ID eliminates air gap between piston and cylinder wall. Adjusting screw remains flush with face of bushing regardless of its adjustment, maintaining a constant over-all length of the component. Linear travel of piston bears a direct, positive relationship to angular rotation of screw, the relationship holding true and constant whether screw is turned clockwise or counterclockwise. Result is an absolute retrace characteristic. All backlash has been eliminated and wear of screw threads is automatically compensated. Special alloy used in piston electrode and adjusting screw results in an extremely low temperature coefficient. Operating temperature range is −55 to +125 C. Dielectric strength is 600 v dc at seal level, and insulating resistance is 10,000 megohms. **Atlee Corp.**, 47 Prospect St., Woburn, Mass.

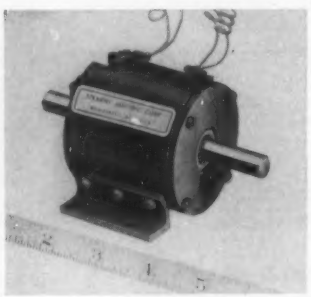


Circle 635 on Page 19

Miniature Clutch-Brake

has both components magnetically set

Miniature clutch-brake, 2.2 SMCB, is a combination in which both clutch and brake are magnetically set. When current is applied to the clutch magnet and not to the brake magnet, the clutch operates. When current is applied to the brake magnet, the brake operates. There is also a neutral position when current to both magnets is turned off, should free wheeling be required. Unit is available in any dc voltage to and including 90 v dc, has a 1.55



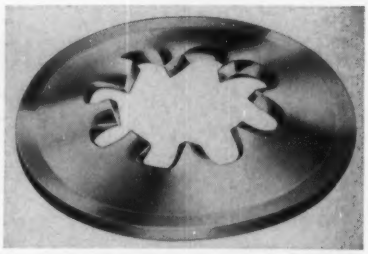
current rating, and has 8 lb-in. torque on both clutch and brake side. It is furnished with bearing-mounted drive and driven shafts, and with foot mounting for ease in adapting in a variety of products. **Stearns Electric Corp.**, 120 N. Broadway, Milwaukee 2, Wis.

Circle 636 on Page 19

Dished Lock Washer

provides surface protection

Smooth, burr-free flat rim of dished lock washer prevents scoring of painted surfaces, plastic parts, and die-cast materials. Surface protection is combined with locking action of a toothed lock washer and spring take-up of a cone washer. Spring take-up compensates for large differentials in expansion between plastics or die-cast materials and steel in the screw. Washer can be made in small sizes to fit recesses or confined areas. It is furnished as a free washer or in Sems and Keps



assemblies. **Shakeproof Div., Illinois Tool Works**, St. Charles Road, Elgin, Ill.

Circle 637 on Page 19

Dry Lubricant

for temperatures from −300 to +500 F

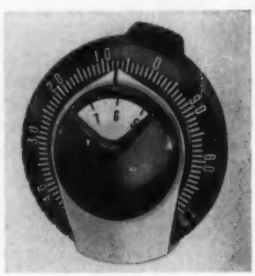
Scientifically formulated, Perma-Slik is a compound of graphitized-molybdenum disulphide in a sprayable suspension that provides a dry, hard, permanently lubricated surface. It stays bonded to the surface even under conditions of extreme pressure and temperature, and will not wash off. Lubricant operates at temperatures from −300 to +500 F. It provides wear protection at pressures to 50,000 psi. Lubricant can be applied to steel, copper, brass, nickel, aluminum, magnesium, plastics, and wood. **Everlube Corp. of America**, 6940 Farmdale Ave., North Hollywood, Calif.

Circle 638 on Page 19

Turns-Counting Dial

for electronic control panels

Five standard models of the series 1360 turns-counting Microdial are available in various combinations of red, gray, and black. Numbers and gradations are molded in depth, and colors are inlays of colored plastic which never wear, scale, or rub off. Dial provides accurate, reliable performance due to smoothness



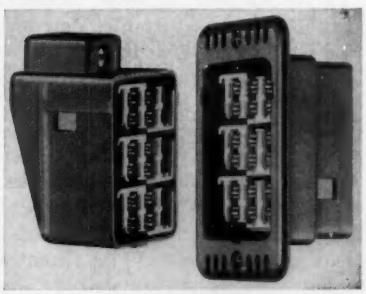
of action, absence of noise, lack of jumping or stepping action, and few ambiguities in reading and setting. Contoured brake arms lock settings in place but do not interfere with reading or setting. **Borg Equipment Div., Amphenol-Borg Electronics Corp.**, 120 S. Main St., Janesville, Wis.

Circle 639 on Page 19

Electric Plugs

have hermaphrodite contacts and insulators

Easily adaptable to many configurations and a variety of layouts, series MH Morpho plugs have hermaphrodite contacts and insulators which fit both plugs and receptacles. Snap-in, crimp-type contacts cut assembly time and facilitate maintenance. Plugs are well-suited to commercial applications such as business machines, computers, and communications equipment. **Cannon Electric Co.**, 3208 Humboldt St., Los Angeles 31, Calif.

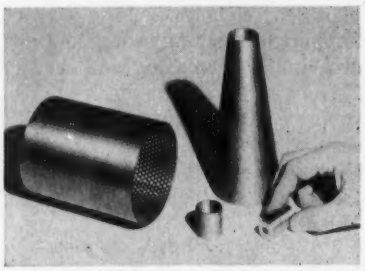


Circle 640 on Page 19

Porous Metal

has high strength and accurate pore size

Low-cost, wound-wire porous metal, Porostrand, is produced as cylinders, cones, and various geometrical figures of revolution. It offers accurate pore-size control with ratings of 10 and 20 microns nominal and 25 and 50 microns absolute. Material is made by winding stranded and solid wires and sintering wires together at all contact points. Open areas between solid wire and strands form the pores. Because of strength and ductility, metal is readily adaptable to grinding, stamping, punching, silver soldering, and welding. It is made from almost



any metal that can be drawn into fine wire. Wire material determines temperature rating of the metal structures. **Bendix Filter Div., Bendix Aviation Corp.**, 434 W. 12 Mile Rd., Madison Hts., Mich.

Circle 641 on Page 19

Two-Component Adhesive

is easy to mix and apply

Two-component adhesive, Stabond EP-110, permits versatile, time-saving bonding methods in the fabrication of metals, glass, wood, thermosetting plastics, hard or vulcanized rubber. Adhesive contains a safety-hardener system for ease of application and nonallergy properties. One component is a blue-colored paste and the other a yellow-tinted hardener. Equal lengths from a tube of each component are squeezed onto a clean, dry surface and mixed until a uniform light-green color indicates thorough blending. Adhesive cures at room temperatures or can be oven-heated for rapid setting. **American Latex Products Corp.**, 3341 W. El Segundo Blvd., Hawthorne, Calif.

Circle 642 on Page 19

Subfractional DC Motor

for instruments, controls, and timing devices

RBD-25 precision subfractional dc motor, mechanically interchangeable

Circle 482 on Page 19

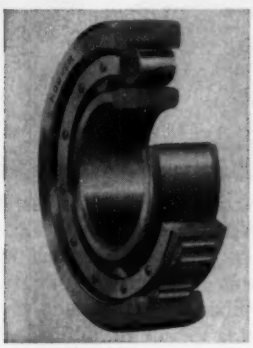
with Holtzer-Cabot synchronous and induction motors of the same frame size, is also available with gear reductions from 3:1 to 3600:1, basic motor speeds from 3600 to 900 rpm, and for voltage ratings from 115 to 24 v dc. Motor is available for instruments, control apparatus, and timing devices. Stock motor is shunt-wound, with 115 v dc field excitation. Armature voltage can be changed from 0 to 115 v dc for speed control. **Holtzer-Cabot Div., National Pneumatic Co. Inc.**, 125 Amory St., Boston, Mass.

Circle 643 on Page 19

Cylindrical Roller Bearings

permit high-speed operation under heavy radial loads

Crowned rollers on new cylindrical roller bearings provide exceptional radial-load capacity for a conventional-size, standard-width, single-row bearing. High-speed operation under heavy radial loads is possible



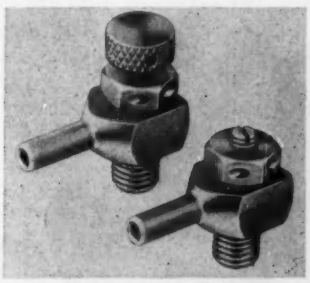
since units are cool running. Retainers are machined solid bronze for strength and accurate roller guidance. Bearings are furnished in three series in a complete range of sizes, and each series provides five variations. **Bearing Div., Hoover Ball & Bearing Co.**, 5400 S. State Rd., Ann Arbor, Mich.

Circle 644 on Page 19

Bleeder Valves

have 360-deg rotatable discharge port

Stainless-steel bleeder valves permit visual check of bleeding or purging of hydraulic lines while pump or system is in operation. Featuring 360-deg rotatable discharge port for directional control of flow, valves can be used with any high-pressure



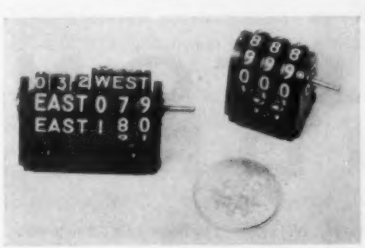
hydraulic system to eliminate fire hazards and afford maximum safety for operating personnel. Valves are available with knurled knob or slotted bleed screw, making them adaptable for a variety of applications. Constructed of 303 and 416 stainless steel, they have a burst pressure over 14,000 psi and can be used with all compatible fluids. Temperature range is from −65 to +275 F. Three sizes are available with 5/16-24, ⅜-24, and 7/16-20 UNF mounting threads. They mate with AND 10050-2, -3, and -4 parts. **Fluid Regulators Inc.**, 313 Gillette St., Painesville, Ohio.

Circle 645 on Page 19

Instrument Counters

for applications requiring low torque and high speed

Two counters have been added to a line of miniature precision instrument counters. They are suitable for any application requiring low torque, durable reliability, and high speeds in a minimum of space and weight. First (right), is a three-figure counter, registering up to 999 and repeat, non-reset. Half-inch diameter wheels are of turned aluminum, with hardened, stainless-steel transfer elements. Shaft is ball-bearing mounted and can be operated at 1500 rpm. Number of variations in the design are available. Second (left), is a tandem counter, equipped with a shutter which is actuated in either direc-



Circle 483 on Page 19→

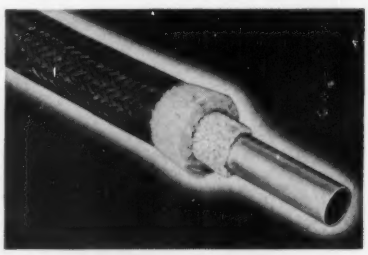
tion whenever a transfer point is reached. It can be adapted for use as a straight six-wheel counter of unusually small size, speed, and ruggedness. Maximum torque is 1½ oz-in. Both counters meet government environmental tests for corrosion, vibration, shock, and humidity. **Veeder-Root Inc.**, 25 Sargeant St., Hartford 2, Conn.

Circle 646 on Page 19

Flexible Tubing

insulates bent pipe or tubing

Insutube, a lightweight, noncombustible flexible tubing is designed for temperatures from 50 to 500 F. It is used for insulating bent piping or tubing where the use of rigid material is impractical, and is also recommended for insulating flexible



connecting lines and for conditions of severe vibration. Product consists of three basic parts: Braided asbestos inner tubing; lightweight, glass-fiber insulation; and an outer covering jacket of braided-asbestos tubing. Tubing is available with an uncoated outer jacket or with an outer jacket coated with oil and abrasion-resistant, self-extinguishing synthetic rubber. Asbestos and glass-fiber components are noncombustible. Tubing is available in sizes from ¼ to 1 in. in increments of ⅛ in., and also in 1½ and 2-in. sizes. All tubes are ½-in. thick. **Fibrous Products Div., Union Asbestos & Rubber Co.**, 1111 W. Perry St., Bloomington, Ill.

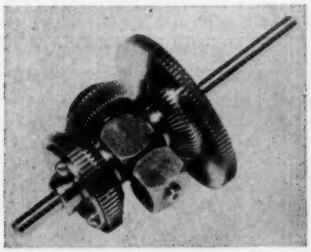
Circle 647 on Page 19

Heavy-Duty Differentials

have interchangeable end-spur clamp rings

Available in both precision-ball and oilless-bearing types, heavy-duty instrument differentials are designated V7 units. They are balanced

Circle 484 on Page 19



with interchangeable end - spur clamp rings, permitting change of end gears upon demand. Variety of end gears is also available in aluminum and stainless steel in pitch ranges from 48 to 120. **PIC Design Corp.**, 477 Atlantic Avenue, East Rockaway, Long Island, New York.

Circle 648 on Page 19

Flexible Base Material

for printed-circuit boards

High-strength material for printed circuits resists peel-back and has excellent temperature, moisture, and dielectric - strength characteristics for VHF and UHF applications. Laminated from Enrad II and glass-fiber cloth, boards have high strength, permitting them to be made as thin as 0.010 in. and to bend in small diameters without cracking or crazing. Boards are made from irradiated polyolefins which resist further radiation and maintain uniform properties. **Enflo Corp.**, Fellowship Road and Route 73, Maple Shade, N. J.

Circle 649 on Page 19

Events Indicator

miniaturized unit weighs only 1.3 oz

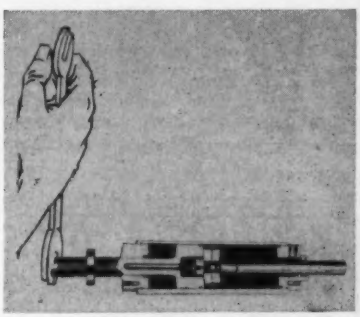
Designed to meet critical environmental and reliability requirements, lightweight miniaturized events indicator meets or exceeds all requirements of MIL-E-5272-B. Electrically activated at 115 v ac, 400 cps, unit draws only 1 w, weighs 1.3 oz, and has 0.680-in. diam by 1.420-in. length. In one-event increments, 1000 events are recorded on the instrument dial; any event which is either initiated or indicated electrically can be registered. Temperature, pressure, or acceleration events, as well as direct on-off events, can be counted. **Elgin Micronics Div., Elgin National Watch Co.**, 368 Bluff City Blvd., Elgin, Ill.

Circle 650 on Page 19

Air and Hydraulic Cylinder

has adjustable stroke

Stroke of new air-hydraulic cylinder is shortened or lengthened easily by turning the rod to fit the application. This is accomplished without disassembling, unmounting the unit or extra parts. Of all steel construction, cylinder has bronze bearing surfaces. Rod has a high yield point, and port can be oriented to any position. End plugs are tapped for universal mounting. Unit delivers smooth, dependable power at high or low speeds. It is available for air at 150 psi and hydraulic use up to 500 psi in 1½ to 8-in. bores with standard, 2:1, or oversize rods. **Ortman-Miller Machine Co.**, 19 143rd St., Hammond, Ind.



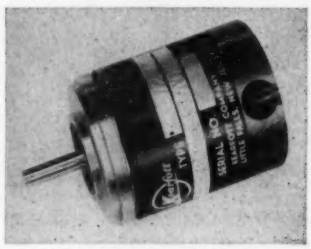
Circle 651 on Page 19

Synchronous Motor

provides constant speed despite voltage variations

R172 Size 11 synchronous motor is a high-performance unit which finds application in timing devices, recorders, and wherever constant speed is required despite load or line voltage variations. It features stainless-steel front and rear bearing retainers. A six-pole motor, it provides synchronous speed of 8000

Circle 485 on Page 19→



rpm and pull-out torque of 0.48 oz-in. It is available with either plain or pinion shaft. **Kearfott Div., General Precision Inc.**, 1150 McBride Ave., Little Falls, N. J.

Circle 652 on Page 19

Gasket Material

for heavy-duty applications

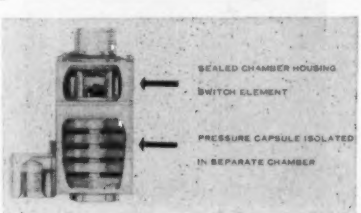
Spaulding 44 gasket material assures easy release without delamination even after long confinement under heavy pressure. Release coating prevents gasket sticking without special graphite coatings. Material resists aromatic fuels and hot oils, making it suitable for gasketing applications in automobile transmissions, rear axles, and gasoline engines. Designed for heavy-duty use, it has tough rag-paper content which insures high tensile strength in both machine and cross-machine directions. Uniform compressibility, thickness recovery after release from pressure, and easy release without damage result from homogeneous-dispersion of Buna-N latex added to rag-paper stock. **Spaulding Fibre Co. Inc.**, 310 Wheeler St., Tonawanda, N. Y.

Circle 653 on Page 19

Pressure Switch

has two compartments in one housing

Model 1600 pressure-actuated switch prevents inflammable media from reaching the switch element or electrical connector in the event of rupture by having two separate compartments in one housing. Switch



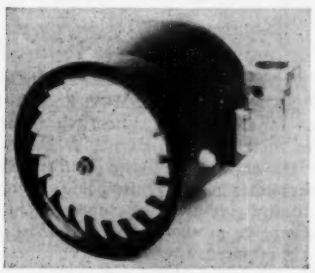
is welded aluminum and operates through a range from 2 to 125 psi. It withstands proof pressures of over 200 psi. Switch operates in temperatures from −300 to +500 F and withstands vibrations to 2000 cps in excess of 25 g acceleration. **Meletron Corp.**, 950 N. Highland Ave., Los Angeles 38, Calif.

Circle 654 on Page 19

Axial-Flow Blower

develops extremely high pressures

Designed like a turbine, axial-flow blower develops pressures to 25 in. water from 4-in. diam axial-flow rotors. Large numbers of thin, highly curved blades are employed. By reducing blade height along air pas-



sages, pressure gradients are carefully controlled. Blower pictured is a 28-v dc unit. Other drives available are 12-v dc, 110-v 60-cycle, and 400-cycle motors. **General Turbine Corp.**, 1338 West Ave., Buffalo 13, N. Y.

Circle 655 on Page 19

Relief Valves

for by-pass oil service

Three hydraulic-system valves are flange type and are designed for by-pass oil-relief service. One 2½-in. model allows control of pressures to 325 lb and the others are specified for maximum operating pressures to 100 lb. Models LFC-9 and LFC-10 are 2½ and 3-in. sizes which employ a spring - loaded piston which starts to open at the set pressure and, under greater pressure, opens completely to allow full-flow by-passing of excess oil. Spring tension can be adjusted to give varying operating pressures. Model HFC-9 (shown) is a 2½-in. flange valve, for 325 lb maximum pressure, which uses a pilot-type operation with two pistons and two springs. All valves have cast-iron

bodies with steel or stainless-steel trim. **Fulflo Specialities Co. Inc.**, 437 Fancy St., Blanchester, Ohio.

Circle 656 on Page 19

Rubber Sheet Stock

resists a variety of chemicals and fluids

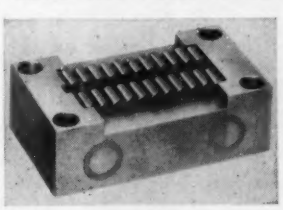
Cohrlastic 975 Viton sheet, with excellent resistance to strong fluids at extremely high temperatures, is available for aircraft and missile parts, automotive applications, oil-well equipment, and chemical processing equipment. A 75-durometer, high-quality stock, it resists such materials as carbon tetrachloride, benzene, and most mineral acids. Resistance to fuels, oils, and lubricants consists of those used in missiles and high-speed aircraft. Heat-aging tests at temperatures from 500 to 600 F show a better elongation retention and less hardness change than previously possible with any commercial elastomer. Sheet is available from stock in 12 x 12 and 24 x 24-in. molded sheets in 1/32, 1/16, 3/32, 3/16, and ⅛-in. thicknesses. **Connecticut Hard Rubber Co.**, 407 East St., New Haven 9, Conn.

Circle 657 on Page 19

Roller-Way Cartridge

has high static and dynamic load capacities

Reduction in breakaway and drag friction in the operation of machine-tool heads and tables is effected



Circle 488 on Page 19→

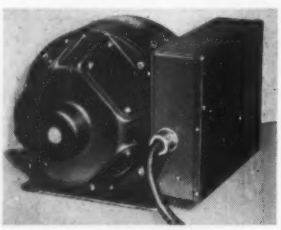
through the use of new roller-way cartridge. High static and dynamic load capacities are made possible by elimination of drilled holes in the bridge, and by control of heat treat. Smaller rollers also contribute to good load distribution and capacity, as well as to positive roller alignment. End caps are manganese bronze, attached to the bridge by precision rings which are press-fitted into annular grooves machined in end cap and bridge, assuring permanent horizontal and vertical alignment of the assembly. Cartridge is available in four standard sizes. **Beaver Precision Products Inc.**, Clawson, Mich.

Circle 658 on Page 19

AC-DC Motors

in ratings through 7½ hp 1800 and 1200 rpm speeds

Ac-dc motors are now available in the integral range. Line is available in ratings from 7½ hp in 1800 and 1200 rpm speeds. Standard open-ventilated motors are packaged with four silicon rectifiers in a bridge circuit which does not require connecting for each type of current. **Industrial Motor Div., Robbins & Myers Inc.**, Springfield, Ohio.



Circle 659 on Page 19

V-Belts

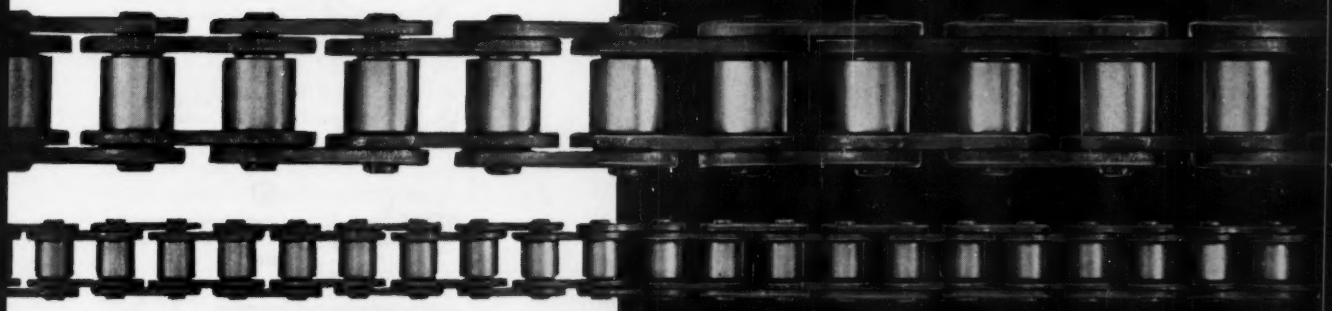
made with synthetic compound are oil, heat-resistant

Available in cross sections of ⅜, ⅝, and 1-in. top width, No. 358 Gripbelts are made with synthetic compound, are oil and heat resisting, and static conducting for the dissipation of static electricity. Belts transmit more horsepower than conventional belts, making possible more compact drive. **Browning Mfg. Co.**, Maysville, Ky.

Circle 660 on Page 19

Tests point way to efficient high-speed drives

the BIG PLUS value



In many chain drive applications, machine designers are seeking more efficient ways to handle higher speeds and greater horsepower. Foreseeing this trend, CHAIN Belt engineers began an intensive program of research into the effects of greater speeds and horsepower on chain life.

Thousands of hours' testing gave definite evidence that new concepts of chain selection were needed in the higher speed ranges. *Shorter* pitch chains were proved to have more horsepower capacity than longer pitch chains at higher speeds. As the chart above shows, the horsepower capacity of a given pitch chain increases to a peak at a definite point in the r.p.m. of the sprocket. Beyond this point, the h.p. capacity of the bushing and roller decreases. But this point is higher for the shorter pitch chain than for the longer. The heavier link plates in the longer pitch chain (Drive No. 1) enable it to handle a greater load at 500 r.p.m. than the shorter pitch chain. At 1500 r.p.m., however, the shorter pitch chain handles a much heavier load.

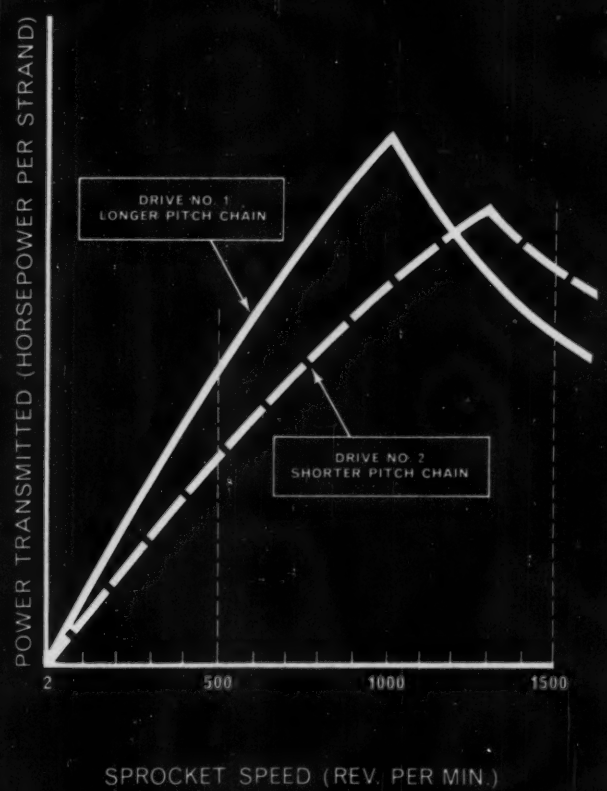
In any given application, there is an optimum pitch and sprocket size that should be used. CHAIN Belt engineers, through their exhaustive testing program, have made determinations that assure the right choice of chain for each type of service. If you have a problem involving higher speed power transmission, we suggest you have your CHAIN Belt man review your requirements. Write CHAIN Belt Company, 4643 W. Greenfield Ave., Milwaukee 1, Wis.

REX®

CHAIN BELT COMPANY

Circle 491 on Page 19

HORSEPOWER CHART FOR ASA ROLLER CHAIN

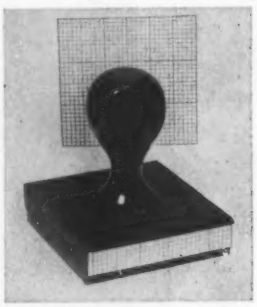


ENGINEERING DEPARTMENT

EQUIPMENT

Rubber Graph Stamp

has pattern of 100 blocks per sq in.



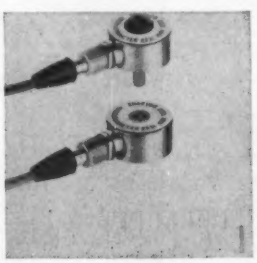
Rubber graph stamp stamps a clear, sharp graph pattern, 3 in. square, wherever it is needed, eliminating the danger of losing or mixing separate graph papers. Stamp has a graph pattern of 100 blocks per sq in. Edmund Scientific Co., Barrington 21, N. J.

Circle 661 on Page 19

Ring-Shape Accelerometer

has first resonant frequency of 25 kc

Model 2221 accelerometer has 0.60-in. diam by 0.43-in. height, and weighs 11 grams. With central mounting hole, No. 6-32 x 5/8 in., it allows connector alignment and standard mounting hardware for ground isolation. Unit has a high first resonant frequency of 25 kc. It provides frequency response from 2 to 4000 cps ±5 per cent with 1000 megohm output, less than 5 per cent cross-axis sensitivity, and operates



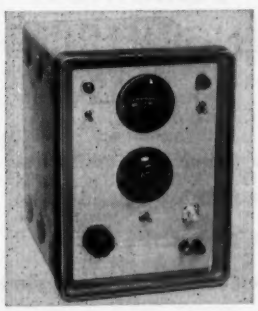
over a temperature range of −40 to +230 F with maximum sensitivity change of ±10 per cent. **Endevco Corp.**, 161 E. California Blvd., Pasadena, Calif.

Circle 662 on Page 19

Sweep or Signal Oscillator

has output impedance of 50 ohms

Type 9128 oscillator has an output frequency of 800 to 1400 mc, output power of 10 mw into a 50-ohm load, and output impedance of 50 ohms. Output power in sweep mode is held flat, with ±1 db over entire sweep range. Sweep mode operates at 30 cps over full range, and manually-tuned mode also tunes over full range. Oscillator operates at fundamental frequency, eliminating problems caused by spurious signals when operating on harmonics or by mixing. Absence of sliding contacts eliminates mechan-



ical wear, noise, or mechanical wiping action. Unit can be used as either a sweep or signal oscillator. **CGS Laboratories Inc.**, 48 Danbury Rd., Wilton, Conn.

Circle 663 on Page 19

Temperature Sensor

measures only ¼ x ⅛ in.

Miniature sensing device is a completely sealed and potted resistance temperature sensor. Measuring only ¼ x ⅛ in., the device is encased in a metal tube which provides additional protection from rigorous environmental conditions. It changes resistance at a rate of 0.393 per cent per deg F, yet tolerance over a wide temperature range is 0.1 per cent. Two leads conduct signals from potted unit to indicator equipment. Sensor is calibrated at a number of

Circle 494 on Page 19

resistance check points from 100 to 400 F. **Dale Products Inc.**, Columbus, Neb.

Circle 664 on Page 19

Roll File

has large-diameter tubes

New Stack Roll File contains four tubes with 4⅞ in. ID to accommodate extralarge plan rolls. Furniture steel housings for four tubes is available in seven sizes from 2 to 5 ft long. Unit can be stacked with basic SRF units to form a single, rigid file, as shown. Spring-latched steel door has tabs to hold 2 x 2-in. color-coded identification card for each tube. **Plan Hold Corp.**, 5204 Chakemco St., South Gate, Calif.

Circle 665 on Page 19

X-YY' Recorder

is two-pen, transistorized unit

Model 480 X-YY' recorder features plug-in input modules for general purpose, computer, low level, differential, time base, curve following, and other specialized functions. The two-pen unit is completely transistorized. Paper size is 11 x 17 in. or 8½ x 11 in., with recording size of 10 x 15 in. Slewing speed on all axes is 30 ips. **Electro Instruments Inc.**, 3540 Aero Court, San Diego 11, Calif.

Circle 666 on Page 19

THE ENGINEER'S Library

Recent Books

Aircraft and Missile Design and Maintenance Handbook. *By Charles A. Overbey; 369 pages, 6¼ by 9¼ in., clothbound; published by The Macmillan Co., 60 Fifth Ave., New York 11, N. Y.; available from* MACHINE DESIGN, *$9.75 per copy postpaid.*

This handbook contains more than 160 tables and 40 figures to illustrate the standard methods of equipment installation and maintenance. Information is applicable to piston-driven and jet planes, helicopters, and guided missiles.

Topics covered are electrical and plumbing systems, construction materials, hardware, color codes and conversion systems, and processes such as metal spraying, anodizing, rust proofing, plating, welding, and brazing.

Creativeness for Engineers. *By Donald S. Pearson, The Pennsylvania State University; 150 pages, 5½ by 8½ in., clothbound; published by Edwards Brothers Inc., Ann Arbor, Mich.; $3.95 per copy.*

A creative approach to the interpretation and solution of engineering problems is thoroughly covered. Problem recognition, definition, and initial evaluation are first discussed. Then, synthesis, analysis, and the final interpretation are covered. This third edition broadens the original scope of the book, particularly in problems requiring analysis.

Association Publications

Non-circular Bevel Gears—Mechanical Engineering Series No. 5. *By Uno Olsson; 190 pages, 7 by 10 in., paperbound; available from Acta Polytechnica Scandinavica Publishing Office, Box 5073, Stockholm 5, Sweden.*

Presented is a method for designing noncircular bevel gears of any shape by using spherical geometry and spherical rolling curves in development, instead of solid geometry

and the conception of rolling cones.

Spherical conic-section curves are used as pitch curves. Mating curves to the spherical conic-section curves are determined. Then, formulas are developed for determining the pitch curve for the mating wheel. Examples of design are liberally used.

Proceedings of the First National Symposium on Nondestructive Testing of Aircraft and Missile Components. 302 *pages, 6¼ by 9¼ in., clothbound; available from Southwest Research Institute, Box 2296, San Antonio 6, Tex.;* $10.00 *per copy.*

General areas discussed were new techniques and methods of instrumentation, application of known testing techniques to special aircraft and missile component requirements, techniques and instrumentation for general applications, and inspection of solid-propellant rocket motors.

Some specific topics included in the 16 papers are new developments in x-ray examination, a new method of radiation thickness gaging, quantitative ultrasonic plotting of small flaws, and updated methods for bearing component inspection.

Government Publications

OTS Technical Reports. Copies of reports listed below are available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C.

PB 151072. Design Information on 5 Cr Alloy Steels for Aircraft and Missiles. By F. R. Morral, R. J. Favor, and W. P. Achbach, all of Battelle Memorial Institute; 48 pages, 8½ by 11 in., paperbound, side-stapled; $1.25 per copy.

Mechanical and physical properties, and metallurgical and manufacturing practices are presented. Elevated-temperature design curves on short-time ultimate tensile strength, tensile and compressive yield strength, ultimate shear strength, bearing ultimate strength, and bearing yield strength are given. Typical stress-strain data are summarized.

PB 151946. Gas-Lubricated Bearings, A Critical Survey. By G. F. Boeker, D. D. Fuller, and C. F. Kayan, Columbia University; 298 pages, 8¼ by 10¾ in., paperbound; $4.00 per copy.

Work on hydrodynamic types of gas-lubricated thrust and journal bearings is discussed. Literature on externally pressurized bearings is critically reviewed according to analysis, design, and performance. Described is an electrical network useful in analyzing pressure and flow relations within various portions of the gas-bearing path.

PB 161103. Technical Resources Directory—Missile Ground Support Equipment. 20 pages, 8 by 10¾ in., paperbound, side-stapled; $0.50 per copy.

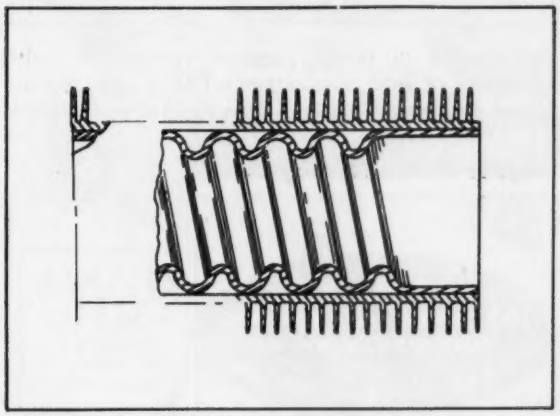
This directory of military agencies responsible for development of missile ground-support equipment was compiled by the Department of Defense. It is divided into Army, Navy, and Air Force sections. Each section lists various components (axles, bearings, etc.), and then the agency and individual having cognizance over the item.

NOTEWORTHY

Patents

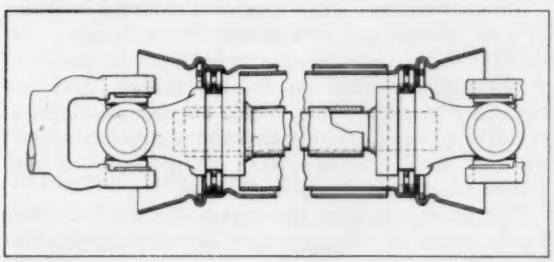
High-Rate Heat-Exchange Tubing

High rate of heat transfer is achieved by heat-exchange tubing with internal corrugations in addition to the usual external fins. Turbulence produced by corrugations in the inner section of a concentric-tube con-



struction promotes the high rate of heat transfer. The inner tube is shaped to provide contact with the center tubing at the crests of the convolutions. *Patent* 2,913,-009 *assigned to Calumet and Hecla, Inc., Calumet, Mich., by Charles H. Kuthe.*

Telescoping-Shaft Guard

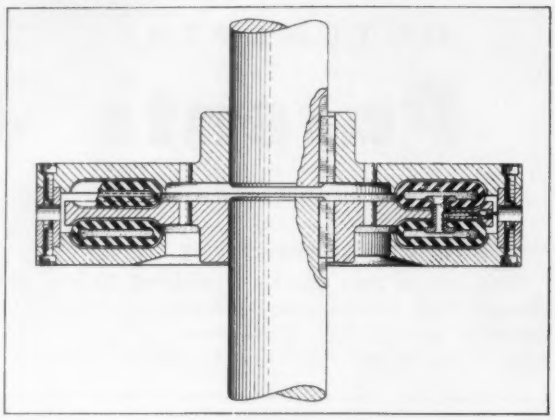


Roller supports serve as anchors for telescoping-shaft shields to permit the shafts to rotate when the shields are arrested. The shields cover the power-transmitting shaft and minimize the danger of injury to personnel. *Patent* 2,924,953 *assigned to Borg-Warner Corp., Chicago, by Charles Edward Cooney Jr.*

Flexible Shaft Coupling

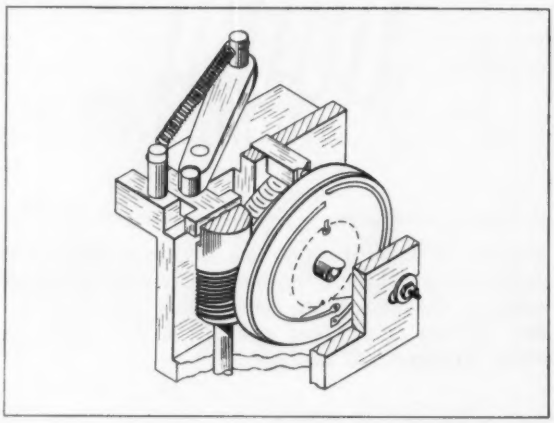
Two inflatable rubber tubes connect the driving and driven members of a coupling assembly. Axial and angular shaft misalignments are accommodated by flexing of the tubes which also damp torsional vibrations transmitted along the shaft. The tubes are in-

Circle 500 on Page 19



terconnected to permit pressure equalization under conditions of axial misalignment. *Patent* 2,919,563 *assigned to General Motors Corp., by Arthur F. Grant.*

Angular-Motion Memory Unit



Storage and feedback of rotational motion is provided by a mechanical unit with electrical controls and a motor. Storable angular motion is fed into the device at a worm-cam member on the input shaft. The cam element engages a T-bar. Slight angular displacement of the input shaft in either direction of rotation actuates the cam and T-bar to move a spring-controlled lever toward the opposite side of dead center.

The worm wheel on the storage-disc shaft is driven by the worm on the input shaft. Any angular displacement of the storage disc disengages a pin on its inside face and a bar follower. Axial movement of the bar follower allows the spring-controlled lever to lock.

Electrical pick-ups on the external face of the storage disc establish contact at the start of storage. Manual interruption of the electrical circuit at the end of the storage period starts the motor to return the disc to the initial position. Simultaneously, the storage disc shuts off the motor and actuates the bar follower, tripping the spring-controlled lever and allowing it to return to the start position. The angular motion required of the motor at the input shaft becomes the measure of the motion stored. *Patent* 2,917,928 *assigned to General Precision Laboratory Inc., New York, by Warren D. Novak.*

HEYCO Nylon STRAIN RELIEF BUSHINGS

The insulating bushing that anchors a cord set to an electrically operated machine or appliance.

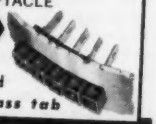
HEYCO JUNCTION-TERMINAL BUSHINGS

ELIMINATE "PIG-TAILS"—MINIATURE SIZE
SNAP-IN ASSEMBLY COLOR CODED
CAN BE USED AS PLUG-IN RECEPTACLE

Provides simple quick disconnect

ACCORDIAN TYPE

Fit curved surfaces
Color & Number coded
Nylon bushing — brass tab



HEYCO NYLON Snap Bushings

10 Sizes for holes from ⅜" to 1½" dia.—various inside diameters. Snap locks into panels up to ⅛" thick.

SAMPLES FREE
ASK FOR THE BUSHINGS OF YOUR CHOICE

HEYMAN MANUFACTURING CO.
KENILWORTH 13, NEW JERSEY
HEY MANI—SAY HEYMAN

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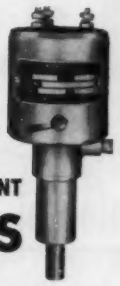
SPEED SENSITIVE SWITCHES



1, 2 & 3 ELEMENT

OVERSPEED

One S.P.D.T. switch to trip at speeds between 500 and 6,000 RPM.

OVER AND UNDERSPEEDS

Two S.P.D.T. switches to trip at two different speeds between 300 and 6,000 RPM.

UNDERSPEED

One S.P.D.T. switch to trip at speeds as low as 250 RPM. Maximum operating speed 5,000 RPM.

OVER INTERMEDIATE AND UNDERSPEED

Three S.P.D.T. switches to trip at three different speeds between 350 and 6,000 RPM.

EXPLOSION PROOF AVAILABLE

The switches listed above are available with explosion proof containers that meet all of the specifications of Class 1, Group D, explosion proof equipment.

For further information ask for Bulletin 504 and 504 A.

SYNCHRO-START PRODUCTS, INC.
8151 N. RIDGEWAY AVENUE, SKOKIE, ILLINOIS

Circle 503 on Page 19

PARAMOUNT Die Castings AT WORK
No. 3 of a Series.

1. Engine Grille Panel
2. Carburetor Access Door
3. Motor Leg Exhaust Cover
4. Lower Shock Mount Cover
5. Upper Gear Housing
6. Lower Gear Housing

PARAMOUNT Die Castings Important on West Bend Outboard Motors

Economy, accuracy, strength and appearance were the factors in the wise choice of aluminum die castings for this sleek 40 H.P. Golden Shark Model by West Bend Aluminum Company.

Engineering and production "know-how" were factors in the selection of Paramount to produce these die castings.

Paramount Can Help You, Too . . .

If your product has die castings, or if you're considering castings, investigate Paramount's complete services.

Three complete plants—two in St. Joseph, Michigan, one in Seymour, Indiana.

SEND FOR "Designing for Die Casting"

PARAMOUNT *Die Casting Co.*
(A Subsidiary of TALON, INC.) ST. JOSEPH, MICHIGAN

Circle 504 on Page 19

Now Available!

PRECISION CLASS I & II anti-BACKLASH GEARS
Custom & Stock
to your requirements
1 or 1,000

STOCK . . . Immediate Delivery
CUSTOM . . . Approx. 3 weeks prototype

STOCK SPECIFICATIONS

Precision Class I and II anti-backlash gears: ⅛" face width, 48, 64, 72, 80, 96 or 120 diametrical pitch, 14½° or 20° pressure angles, diameters from ⅛" to 2". Available in 24ST aluminum with solid or clamp type 303 S.S. hubs with choice of 0.125", 0.1875" or 0.250" bores.

CUSTOM AB GEARS TO YOUR SPECS AND DRAWINGS

FREE!

Send for supplements to DYNACO E88 Catalog. Shows complete line & specs. on precision stock differentials and new, miniaturized line of precision stock gears.

DYNAMIC GEAR CO. INC.
AMITYVILLE, NEW YORK

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MACHINE DESIGN is sent at no cost to management, design and engineering personnel whose work involves design engineering of machines, appliances, electrical and mechanical equipment, in U. S. and Canadian companies employing 20 or more people. Copies are sent on the basis of one for each group of four or five readers. Consulting and industrial engineering firms, research institutions and U. S. government installations, performing design engineering of products are also eligible.

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BPA NBP

backtalk——

—Meet McGraw

Anthony F. McGraw, that is, new assistant editor of MACHINE DESIGN. Tony has collected a string of letters after his name—a Ph.B. (bachelor of philosophy) from Marquette University, an M.A. from Southern Methodist, and an M.S. in library science from Western Reserve. He has also studied law.

Tony taught English at SMU; worked in the science and industry division of the Dallas Public Library; and for the last two years has been with the Cleveland Public Library, most recently as head of the science and technology department. During his years among the technical books, he was often called upon for assistance in preparing articles, and it was not uncommon for him to write an entire paper.

Despite the fact that his previous work involved reviewing a dozen or so technical books each week, Tony enjoys leisure-time reading. For physical relaxation he likes to bowl, hunt, fish, and hike.

—Responsive Reading

We have vowed never to stuff this page with excerpts from letters asking for tearsheets of articles; however, we feel that some unusual requests do bear repeating.

Two such inquiries were answered recently —one concerning a 12-year-old article; the other, a 12-year-old reader. The latter is a young lady in Chicago whose father reads MACHINE DESIGN and, apparently, passes his copies along to her. Papa called our Chicago office to obtain tearsheets of the March 3 article, "Medical Engineering," explaining that his daughter needed them for her school work.

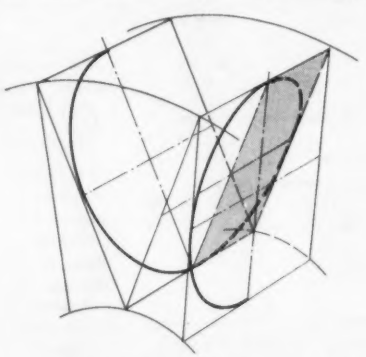
The other inquiry is from the Barden Corp., ball-bearing maker of Danbury, Conn., asking permission to reprint "Superprecision Ball Bearings." This series, by Thomas E. Rounds, then chief engineer of Barden, appeared in 1948 and 1949, and Barden obtained 2500 reprints. The last paragraph of their letter reads:

> You'll be interested to know that, although the article is now some 12 years old, it is still considered a most complete and authoritative account of superprecision ball bearing selection. Surprisingly enough, we have recently had an increased number of inquiries for the piece—hence, our need to reprint. I would say that both MACHINE DESIGN and Mr. Rounds deserve commendation for this unusual length of life for such an article.

—Behind the Cover

Picture, if you will, a piece of spaghetti wound around a doughnut—not to eat, but to draw in perspective. This approximates George Farnsworth's problem in creating this issue's cover illustration of the goings-on inside a fluid coupling. The doughnut, of course, corresponds to a torus; the spaghetti, to the curved helical path of the hydraulic fluid. With an armful of paper and pencils, an MD article on drawing ellipses, and his own inspired determination, George produced his cover.

The side view of the hydraulic spaghetti would be a bent sine wave; George used the tentlike construction shown here to approxi-



mate it. The solid curved line is the "out" path of the fluid; the dotted line, the "in" flow, on another plane.

George called this torus-helix creation by various and uncomplimentary names during its development, but when it was finished and he stood back to regard it, he beamed, "Look—I've drawn a torix!"

Advertising Index

At last!

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A

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It was Designed to Provide: High Horsepower in a Smaller Unit • Centrifugally Cast Bronze Gears • Alloy Steel Worms Heat Treated By An Exclusive Process for Carrying Higher Loads • Fan Cooling for More Efficient Operation • Maximum Overhung Load-Carrying Capacity • Ribbed Housing for Maximum Strength and Heat Dissipation • Modern, Streamlined Design to Enhance Your Machine's Appearance.

Cleveland's new speed reducer line meets AGMA Standard 440.03 — which permits higher horsepower and torque ratings — provides you speed reduction at savings of 50% or more on cost per horsepower. All this, with no deviation from Cleveland's standards of quality and dependability.

Remember, this strikingly new line of fan-cooled reducers — now available from one to forty horsepower — incorporates all the design knowledge gained by Cleveland's engineers over the past 47 years — plus all the advantages of modern metallurgical techniques and advanced manufacturing processes. Consult your Cleveland Representative for the complete story on this new speed reducer — or write us direct for Bulletin No. 405. It details input horsepower and output torque ratings, service factors, application and load classifications, as well as general over-all dimensions.

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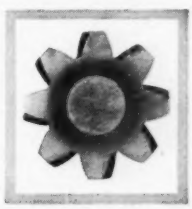
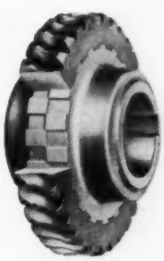
EATON

Check these new exclusive Cleveland features



Cleveland's Worm's, heat-treated by an exclusive process, possess a high degree of hardness throughout their entire thread thickness — and well below the worm's root diameter. This gives maximum thread strength and resistance to wear without losing the advantage of a tough core of medium hardness.



Centrifugal cast bronze rims have a greater density and a higher hardness, giving increased resistance to wear and fatigue pitting. They are centrifugally cast integral with cast iron centers on 6″ and smaller sizes. This permits strong mechanical keying of the two parts — without dependence on actual surface bond. Gear shaft extension diameters are especially large to permit greatly increased overhung load capacity.

CLEVELAND
Worm Gear
Speed Reducers

Worm and gear shaft bearings are Timken taper roller type, providing adequate thrust and radial capacity. Worm bearings are mounted directly in the housing bore for greater rigidity.

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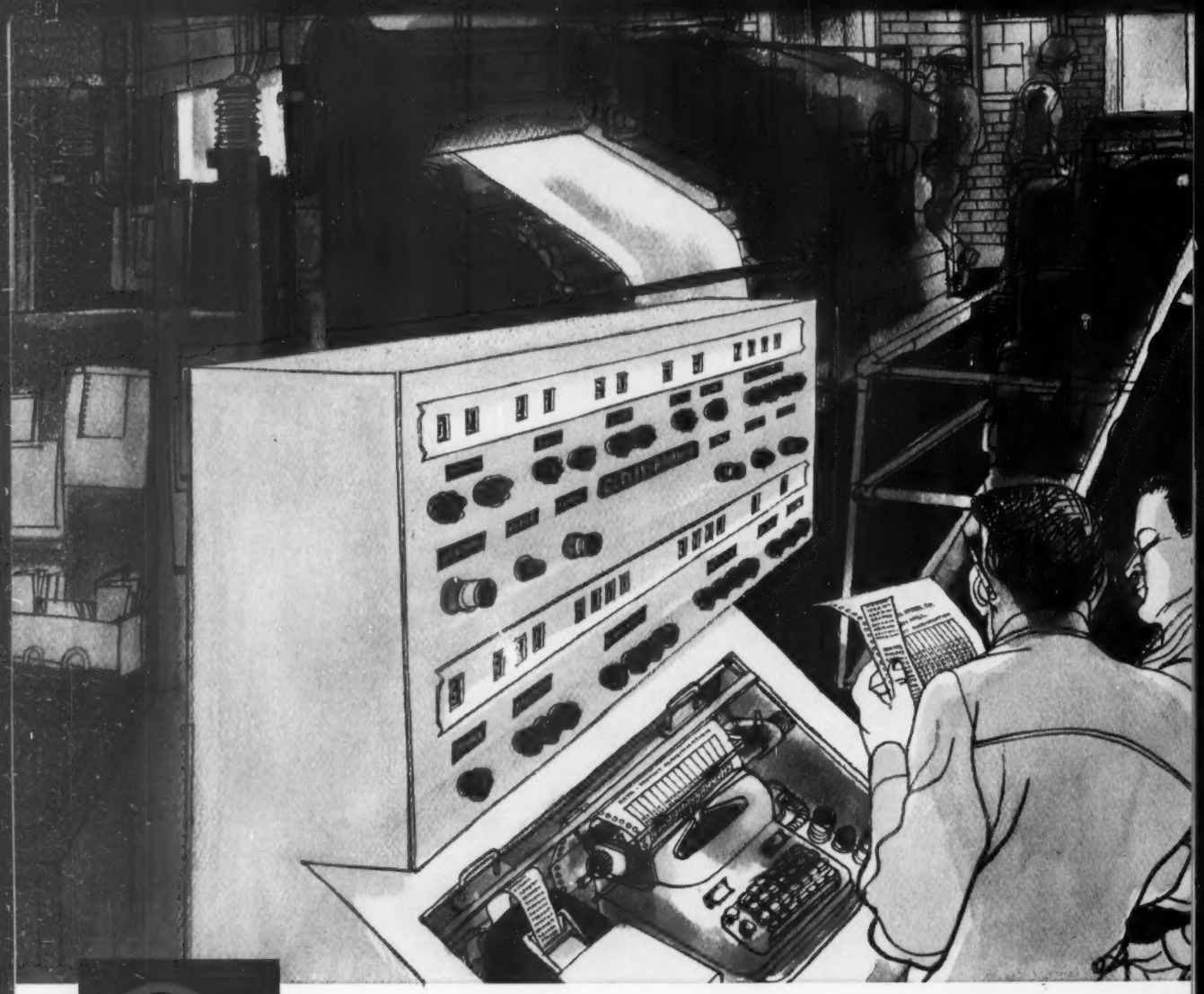

CONTROL

New machine with a memory licks a quality problem 3 miles long!

It's relatively simple to control quality of tinplate sheets by running them individually through sensing stations. But, how do you check and control quality in a *coil* of tinplate up to 16,000 feet long?

Working with a leading tinplate producer, Cutler-Hammer engineers devised an ingenious new type of computer that hooks right onto the sensing stations and automatically keeps track of every defect. When the tape is checked, production controls can be quickly adjusted to compensate for any deviation from standard.

This is an example of the new thinking, the new vitality at Cutler-Hammer. We're on the move . . . with new products, new ideas, new engineering talent. We've solved problems that other companies in our field wouldn't even tackle. One of our divisions, with extensive microwave and electronic experience, gives us even more creative muscle in all fields of industrial automation.

Even our trademark's new, to symbolize the new Cutler-Hammer. Phone one of our sales offices and see how we can fit on your team.

WHAT'S NEW? ASK...

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CONTROL

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